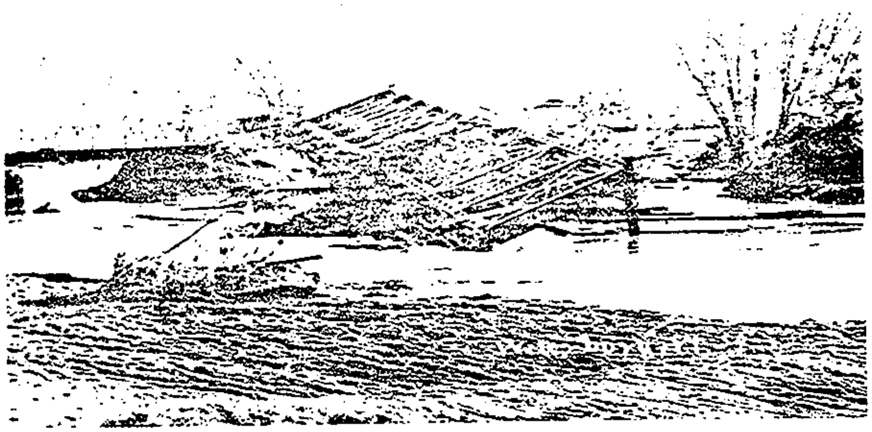
FLOOD PLAIN INFORMATION

WINOOSKI RIVER – LITTLE RIVER – THATCHER BROOK

TOWN OF WATERBURY • VERMONT



PREPARED FOR

DEPARTMENT OF WATER RESOURCES, STATE OF VERMONT

BY

DEPARTMENT OF THE ARMY, NEW YORK DISTRICT, CORPS OF ENGINEERS

MARCH 1973

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NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK
GENERAL MAP
WINOOSKI RIVER
VERMONT
1 0 1 2 MILES
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PLATE 1

PREFACE

That portion of the Winooski River Basin extending from Bolton Falls upstream for a distance of about seven miles through the Town of Waterbury to the Middlesex town line, including the lower ends of Little River and Thatcher Brook, is covered by this report. The properties on the flood plains along these streams are mainly residential, commercial, agricultural and governmental. They have been damaged by sizeable floods in 1830, 1869, 1912, 1927, 1933, 1936 and 1938. The open spaces on the flood plains are under pressure for future development. Although large floods have occurred in the past, studies indicate that even larger floods are possible.

This report has been prepared because a knowledge of flood potential and flood hazards is important in land use planning and for management decisions concerning flood plain utilization. It includes a history of flooding in the Waterbury area and identifies those areas that are subject to possible future floods. Special emphasis is given to these possible future floods through maps, photographs, profiles, and valley cross sections.

The report does not provide solutions to flood problems; however, it does furnish a suitable basis for the adoption of land use controls to guide flood plain development and thereby prevent intensification of the flood loss problems. It will also aid in the identification of other flood damage reduction techniques, such as works to modify flooding and adjustments including floodproofing which might be embodied in an overall flood plain management [FPM] program. Other FPM studies — those of environmental attributes and the current and future land use role of the flood plain as part of its surroundings — would also profit from this information.

Under the continuing authority provided in Section 206 of the 1960 Flood Control Act as amended, this report was prepared in response to the request of the Department of Water Resources, State of Vermont. The Department will make information available to all interested agencies and individuals. Upon further request, the Corps of Engineers, New York District Office, will provide technical assistance to planning agencies in the interpretation and use of the data presented, as well as planning guidance and further assistance, including the development of additional technical information.

BACKGROUND INFORMATION

Settlement

The Town of Waterbury was established under a charter granted by King George III to Benning Wentworth, Esq., June 7, 1763. Its first settler arrived in 1783, 20 years later. The first Town Meeting was held in March 1790. The Central Vermont Railroad was completed from Middlesex into Waterbury in 1849. In 1882, the Village of Waterbury was incorporated by Act of the Vermont Legislature.

In 1890, the first building of the Vermont State Hospital for the Insane was constructed in Waterbury. In 1927, at the time of the Great Flood, there were 872 patients and 180 employees. By 1963, the number of employees had increased to about 450 and the number of patients to about 1,200.

According to the 1970 census report, the Town of Waterbury had a population of 4,614, including approximately 1200 at the State Hospital. Of this total, 2,840 were included in the population of the Village of Waterbury.

Although there is a small amount of industrial activity in the Town, more than half of the work force is engaged in State Hospital related activities.

The major highways through the Town are Interstate Route I-89, U.S. Highway 2, and State Highway 100. The main line of the Central Vermont Railroad runs through the Town paralleling the Winooski River with the railroad embankment forming a barrier in many places to the overflow of flood waters.

The Stream and Its Valley

This report encompasses that portion of the Winooski River from the dam at Bolton Falls upstream to the Waterbury-Middlesex town line, a distance of about seven miles, together with short segments of Little River and Thatcher Brook, tributaries to the Winooski River flowing from the north.

Bolton Dam, which had a crest elevation in 1927 of 393.4 feet above mean sea level, has deteriorated to where the crest is now at elevation 382.1 feet. It controls to a limited extent the elevation of the water surface upstream. A more far reaching control, however, is the constriction of Bolton Gorge itself, where flood waters are forced to flow through a deep channel only 40 feet wide at its upstream end. Upstream from this constriction, the flood plain expands to as much as 2,400 feet or more in width.

As a result of the contraction at Bolton Gorge, as much as 10 per cent of the peak flow of a large flood may bypass the gorge through a railroad cut on the south side of the valley. Upstream from the gorge, an extensive flood plain extends through most of the study area, including the lower portions of Little River and Thatcher Brook.

Development in the Flood Plain

The first three miles of the Winooski River flood plain up to the Village of Waterbury is sparsely settled and used mostly for agricultural purposes. However, there are a number of residences, including several mobile homes on the flood plain, that would be subject to extensive damage or destruction with possible loss of life to residents, should a flood of either Intermediate Regional or Standard Project Flood proportions occur. Commercial establishments are gradually encroaching onto the flood plain.

Much of the Village of Waterbury, including buildings of the State Hospital which house 1,200 patients and 450 employees, would be affected by floods of both magnitudes discussed in this report. In some parts of the Village, damage would result from inundation from ponding or slowly moving water. In other areas, damage would be more extensive due to inundation together with the force of rapidly flowing water.

At several points, tracks of the Central Vermont Railroad would be under water as well as portions of U.S. Highway 2, Vermont Highway 100, and for a short distance Interstate Highway I-89.

The Standard Project and Intermediate Regional Floods would overtop the decks of the Main Street and Winooski Street Bridges. The railroad bridge, west of the Village, would be overtopped by the Standard Project Flood.

Three bridges over Thatcher Brook would be submerged as would Old Route 2 Bridge over Little River.

FLOOD SITUATION

Data Sources and Records

Records of river stages and discharges in the Winooski River Watershed have been maintained by the U.S. Geological Survey since 1909 when a chain gage was installed at the Montpelier site on the Winooski River. At present, there are eight gaging stations in the Winooski River Watershed. Table 1 gives a list of these stations, along with the periods of record, drainage areas, and the maximum discharges of record.

TABLE 1
STREAM GAGES - WINOOSKI RIVER WATERSHED

Name of Station	Stream	Period of Record	Drainage Area [Sq. Mi.]	Maximum Discharge [C.F.S.]	Date
Essex Junction*	Winooski R.	1928-1972	1044	113,000	11/1927
Montpelier*	Winooski R.	1909-1923 1928-1972	397	57,000	11/1927
Northfield Falls	Dog River	1934-1972	76.1	9,750	9/1938
East Barre*	Jail Branch	1920-1923 1933-1972	40.4**	11,500	11/1927
Wrightsville*	North Branch	1933-1972	69.2	17,200	11/1927
Waterbury*	Little River	1935-1972	111	23,400***	11/1927
Moretown	Mad River	1928-1972	139	23,000	11/1927
Near Montpelier	Sonny Brook	1963-1972	2.3	164	5/1964

* Flow affected by upstream flood control reservoirs. The East Barre and Wrightsville Reservoirs have been in operation since 1935. The Waterbury Reservoir has been in operation since 1937.

** Includes 11.3 square miles of area diverted for East Barre Water Supply.

***No regulation.

To supplement the records at the gaging stations, newspaper files, historical documents and records, and interviews with local residents provided data for a more complete evaluation of the flood situation.

Maps prepared for this report were based on photogrammetry prepared in 1967 and 1972 modified by "as built" plans for Interstate Highway I-89 which was completed subsequent to 1967. Flood plain cross sections were surveyed by Vermont Department of Water Resources employees in 1971. Structural data on bridges and the capacity of the river channels to convey flood flows were field checked in 1972.

Crest stages for the 1927 flood are shown in Table 5.

Flood Season and Flood Characteristics

Major floods have occurred in the study reaches of the Winooski River, Little River, and Thatcher Brook during all seasons of the year, with the greatest known flood since 1830 occurring in November 1927. Flood flow stages on Little River and Thatcher Brook can increase fairly rapidly from normal flow to extreme flood flow. Because of the size of the watershed and extensive areas of the flood plain, the rate of rise of the Winooski River is less rapid than on smaller streams with narrow flood plains.

The precipitation in the November 1927 storm was fairly general over the entire watershed and consisted entirely of rainfall. Other floods have resulted from a combination of rainfall and snowmelt.

Factors Affecting Flooding and Their Impact

Obstructions to Floodflows

Natural obstructions to floodflows include trees, brush, and other vegetation growing along the stream banks and in the floodway areas of the flood plain. Natural constrictions in the floodway, such as ledge outcrops also obstruct floodflows. Man-made encroachments on or adjacent to streams, such as dams, bridges, and buildings, can create more extensive flooding upstream of the encroachments than would otherwise occur. Representative obstructions to floodflows are shown in Figures 2 through 8.

During floods, trees, brush and other vegetation growing in floodways impede floodflows, creating backwater and increased flood heights upstream. Trees and other debris may be washed away and carried downstream to collect on bridges and other obstructions to flow. As floodflow increases, masses of debris may break loose and permit a wall of water and debris to surge downstream until another obstruction is encountered. During the winter months, ice cakes can behave in a similar manner. Debris and/or ice may collect against a bridge or other structure until the load exceeds the structural capacity of the obstruction and the structure is destroyed. The limited capacity of obstructive bridges retards floodflows and results in additional flooding upstream, erosion around the bridge approach embankments, and possible damage to the overlying roadway.

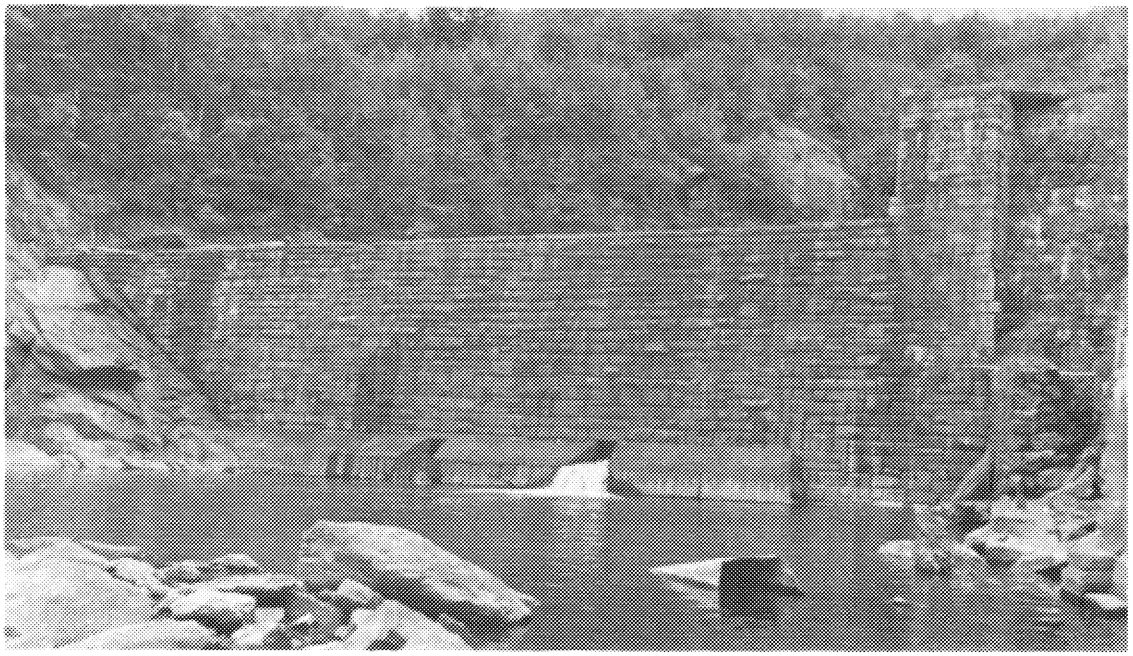


Figure 1 - Dam on Winooski River at Bolton Falls below Waterbury. Dam spills except during extreme dry spells.

Figure 2 - Abandoned Route 2 Bridge over Little River. Bridge opening inadequate to pass major flood.

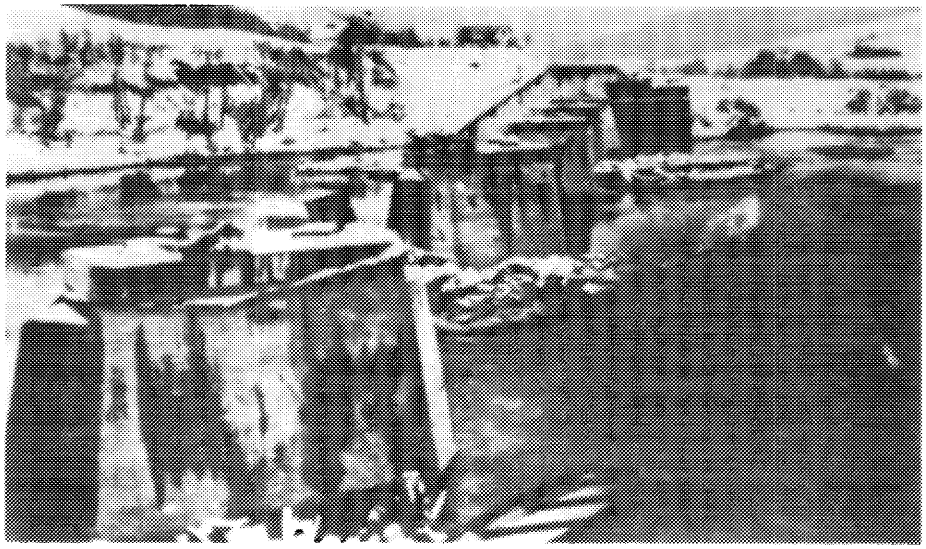


Figure 3 - Famous "Bridge 71" as the flood left it in 1927. Where 440 feet of 100 ton steel spans were swept downstream under the impact of floating buildings and wooden bridges.

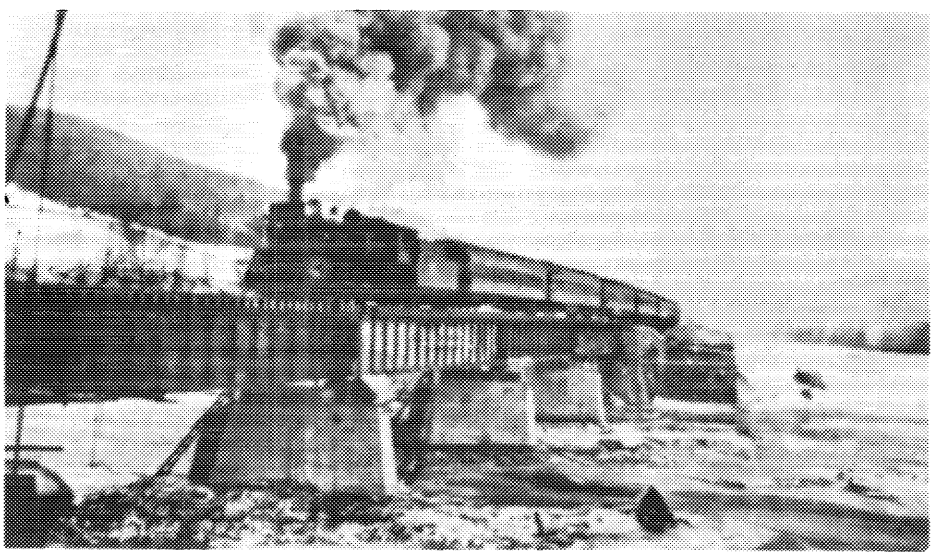


Figure 4 - After 92 days and nights (February 1928). Showing Sir Henry Thornton's "First Train" over the reconstructed Central Vermont and Bridge 71 at Waterbury, the last link to be repaired.

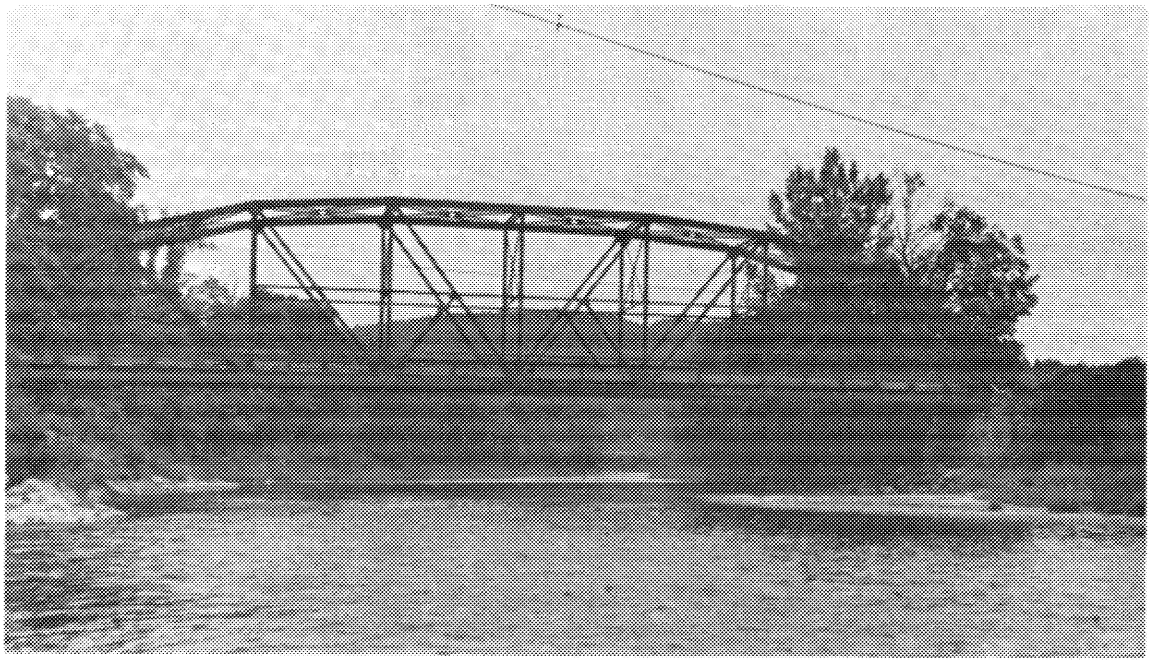


Figure 5 - Winooski Street Bridge at Waterbury. Former bridge destroyed in 1927 flood. Bridge opening inadequate to pass either IRF or SPF.

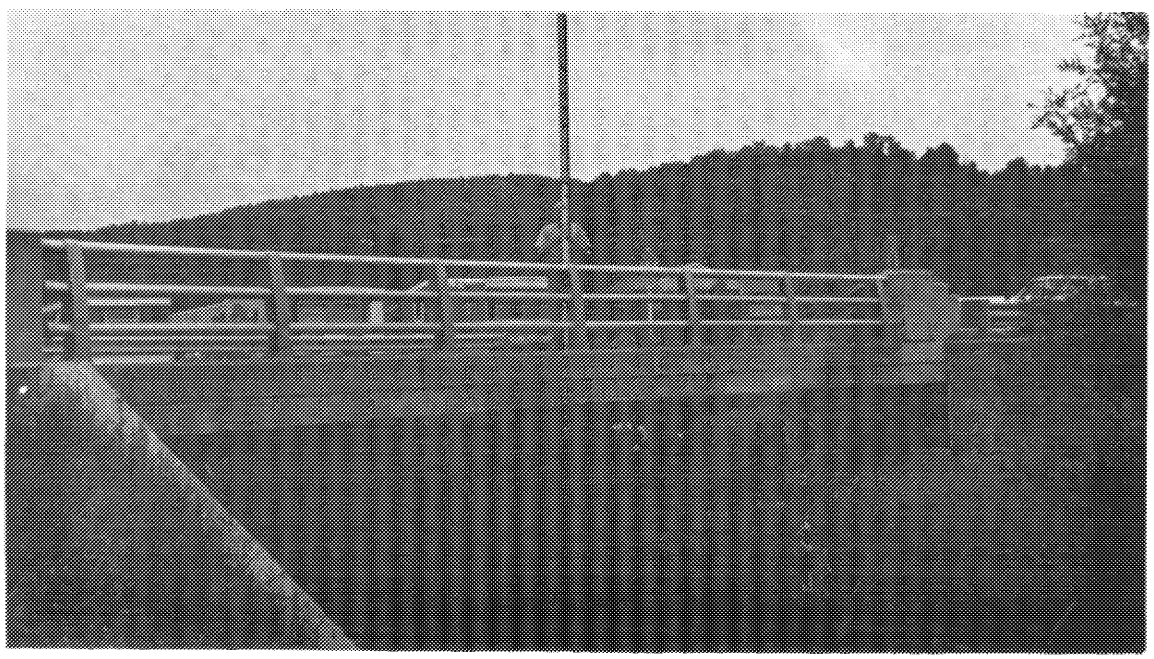


Figure 6 - Bridge on Armory Drive over Thatcher Brook. Bridge would be completely submerged by both IRF and SPF.

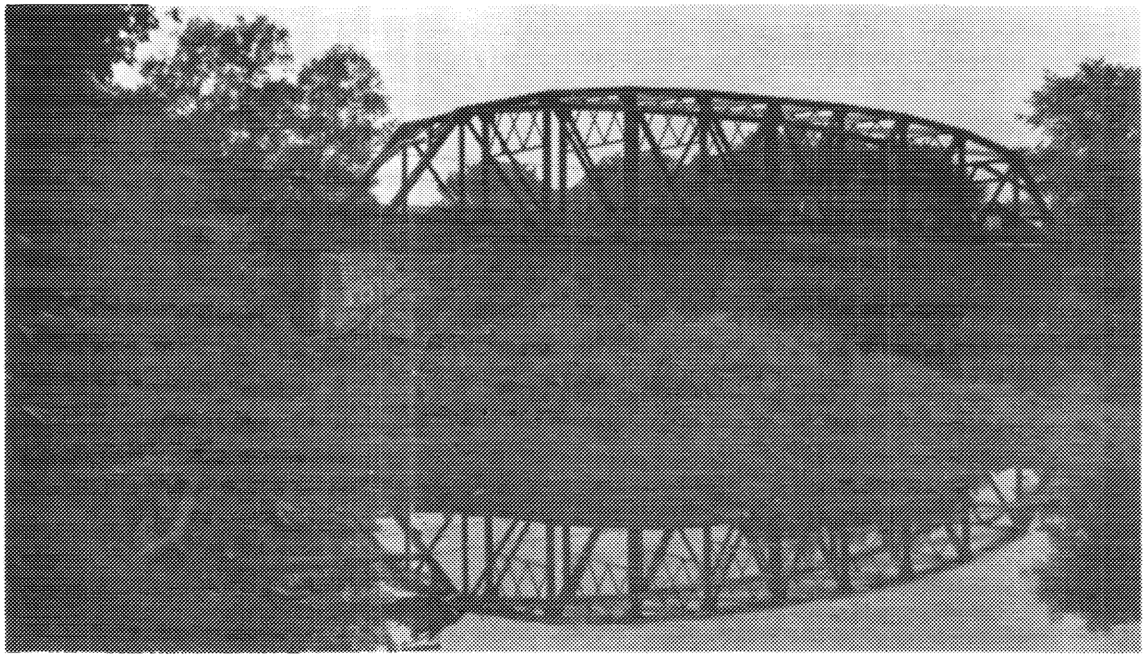


Figure 7 - Winooski River Bridge, So. Main Street, Waterbury, looking downstream. Note debris deposited, reducing effective channel capacity.

Figure 8 - Former bridge at above site, destroyed in 1927 flood.

In general, obstructions restrict floodflows and result in overbank flows and unpredictable areas of flooding, destruction of or damage to bridges, and an increased velocity of flow immediately downstream. It is impossible to predict the degree or location of an accumulation of debris and/or ice; therefore, for the purpose of this report, it was necessary to assume in the development of the flood profiles that there would be no accumulation of debris and/or ice to clog any of the bridge openings.

The dam at Bolton Falls has no appreciable flood control capacity, nor will it alter seriously the flow characteristics since its effect is largely nullified by the constriction of Bolton Gorge upstream from the dam.

Winooski River, Little River and Thatcher Brook are spanned by nine bridges within the study area. Pertinent information on all bridges can be found in Table 5 on Page 23.

Flood Damage Reduction Measures

Following the catastrophic flood of 1927, studies of flood damage reduction measures were made and by 1937 two detention type reservoirs and one reservoir combining flood control and storage of water for power were completed.

The detention type reservoirs, East Barre and Wrightsville, were completed in 1935. Neither dam has gates, release of stored flood water being through a fixed outlet opening 7 feet high by 3.7 feet wide at East Barre (since modification in 1959) and through an outlet opening 5.25 feet square at Wrightsville. In 1937, the dam on Little River (Waterbury River) creating Waterbury Reservoir was completed providing more than 1.2 billion cubic feet of flood storage between the elevation of the sill of the taintor gate and the crest of the spillway.

In addition, limited flood storage is available at Peacham Pond and Mollys Falls Reservoir which were constructed and are operated for power generation. Combined, these two reservoirs regulate runoff from 24 square miles of watershed, and have a usable capacity of 492 million cubic feet. Only a part of this capacity would be available for storage of flood water, however, since reservoirs for power generation seldom are wholly depleted. Some flood peak reduction usually would be realized since it is improbable that the reservoirs would be entirely full at the time of a flood.

There are no additional flood control projects authorized for the study area or upstream in the Winooski River Watershed at this time.

Through the operation of the two detention type reservoirs, the peak flow from 106 square miles of the total of 706 square miles upstream from Waterbury is reduced to considerably less than natural flow and flood peaks reduced materially all the way downstream to the mouth of the Winooski River.

Additional flood control is provided on the Winooski River below Waterbury by storage of flood waters in Waterbury Reservoir with a drainage area of 109 square miles, situated on Little River 2.7 miles upstream from its mouth. Records of flow in Little River, one mile downstream from the reservoir, are available since 1935 at a U.S.G.S. gaging station. A maximum flow rate of 6,520 cubic feet per second was recorded at this site in March 1936. The peak flow in November 1927 was estimated as 23,400 cfs. Since completion of the reservoir in 1937, a maximum peak flow rate of 4,080 cfs at the gage was recorded.

Flood control facilities such as those at East Barre, Wrightsville, and Waterbury Reservoir have one undesirable feature, however. They tend to give property owners downstream of the structures a sense of security from damage from all future floods. It is recognized that such reservoirs reduce the magnitude of floods, but they do not prevent floods. Heavy rain and/or snowmelt on the 600 square miles of uncontrolled watershed above Waterbury can and do produce major flooding. The 1936 and 1938 floods substantiate this contention.

Flood plains, and in particular the floodways, should be looked upon as highways for transporting water and should be kept clear of obstructions.

Other Factors and Their Impact

Flood Warning and Forecasting

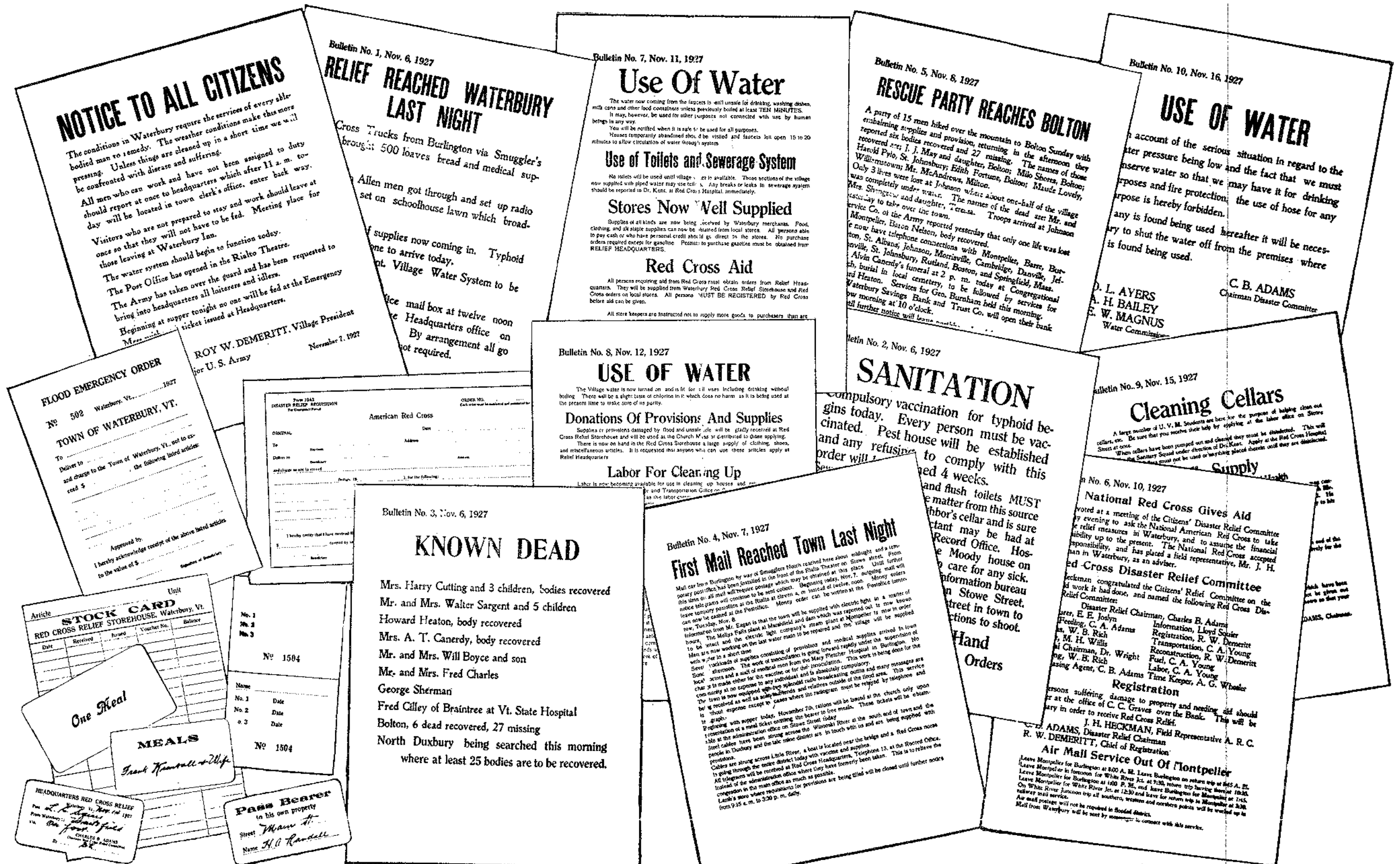
The National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce maintains year-round surveillance of weather conditions at Montpelier, Burlington and elsewhere in the Winooski Watershed. Flood warnings and statements of anticipated weather conditions are issued by the National Weather Service in Burlington, Vermont, and the River Forecast Center in Hartford, Connecticut. During floods or potential flood periods, the Weather Service Office releases, at 24 hour intervals or as may be necessary, an appropriate forecast of the high water elevations that may be expected at the stream gaging stations operated by the U.S. Geological Survey along the Winooski River and its tributaries. The River Forecast Center in Hartford and the Weather Service Office at Burlington disseminate the information to the State Police and to Civil Defense Organizations. In addition, in response to inquiries, flood forecasts are supplied to newspapers, and radio and television stations which usually issue forecasts in descriptive terms such as "Approaching bankfull" or "One to two feet above bankfull."

Flood Fighting and Emergency Evacuation Plans

Although there are no formal flood fighting or emergency evacuation plans for the Waterbury area, provisions for alerting area residents and coordinating operations of town, county and State public service agencies in time of emergency are accomplished through the Montpelier Civil Defense Office.

Material Storage on the Flood Plain

Due to the development along the Winooski River, there are considerable quantities of floatable materials stored on flood plain lands. Notable are piles of lumber and other building materials, and a number of storage tanks for gasoline and natural gas. During time of floods, these floatable materials, together with small wooden outbuildings, may be carried away by floodflows causing serious damage to structures downstream and could clog bridge openings creating more hazardous flooding problems.


NOTICE TO ALL CITIZENS
ROY W. DEMERITT, Village President
November 7, 1927
Bulletin No. 1, Nov. 6, 1927
RELIEF REACHED WATERBURY LAST NIGHT
Bulletin No. 7, Nov. 11, 1927
Use Of Water
Use of Toilets and Sewerage System
Stores Now Well Supplied
Red Cross Aid
Bulletin No. 5, Nov. 8, 1927
RESCUE PARTY REACHES BOLTON
Bulletin No. 10, Nov. 16, 1927
USE OF WATER
C. B. ADAMS
FLOOD EMERGENCY ORDER
TOWN OF WATERBURY, VT.
American Red Cross
Bulletin No. 8, Nov. 12, 1927
USE OF WATER
Donations Of Provisions And Supplies
Labor For Cleaning Up
Bulletin No. 2, Nov. 6, 1927
SANITATION
Bulletin No. 9, Nov. 15, 1927
Cleaning Cellars
Bulletin No. 6, Nov. 10, 1927
National Red Cross Gives Aid
Registration
Air Mail Service Out Of Montpelier
STOCK CARD
RED CROSS RELIEF STOREHOUSE, Waterbury, Vt.
One Meal
MEALS
HEADQUARTERS RED CROSS RELIEF
Pass Bearer
Bulletin No. 3, Nov. 6, 1927
KNOWN DEAD
Mrs. Harry Cutting and 3 children, bodies recovered
Mr. and Mrs. Walter Sargent and 5 children
Howard Heaton, body recovered
Mrs. A. T. Canerdy, body recovered
Mr. and Mrs. Will Boyce and son
Mr. and Mrs. Fred Charles
George Sherman
Fred Gilley of Braintree at Vt. State Hospital
Bolton, 6 dead recovered, 27 missing
North Duxbury being searched this morning where at least 25 bodies are to be recovered.
Bulletin No. 4, Nov. 7, 1927
First Mail Reached Town Last Night

PAST FLOODS

Summary of Historical Floods

Damaging floods have been reported to have occurred in the Winooski Valley, including the Waterbury area, in 1785, 1810, March 1826, September 1828, July 1830, October 1869, April 1912, November 1927, April 1933, March 1936, and September 1938. The most damaging of these floods was that in November 1927 at which time a peak rate of flow of 97,500 cubic feet per second was estimated at Bolton Dam. Flood marks indicate a water surface elevation of approximately 433.5 feet at Bolton Dam and of about 437 feet at the railroad bridge west of Waterbury, and through the Village of Waterbury.

More recent flood elevations have been lowered from what they might otherwise have been by the deterioration of Bolton Falls Dam and by the operation of detention reservoirs on the North Branch-Winooski River at Wrightsville and on Jail Branch at East Barre, construction of which was completed in 1935. Dowstream from the mouth of Little River west of Waterbury, flood peaks have been reduced further by the operation, since 1937, of Waterbury Reservoir on Little River.

Streamflow Records

Since 1928, a continuous record of flow of the Winooski River at Montpelier has been obtained by the United States Geological Survey at a point where the watershed area drained is 397 square miles. Records of streamflow which are collected in the Winooski River Basin are listed in Table 1 on Page **3**.

Unfortunately, none of the gages was in operation in 1927, at the time of the greatest flood known since 1830. However, the Montpelier gage had been operated from May 1909 to June 1914 (fragmentary records) and from July 1914 to September 1923. It was thus possible to estimate the flood peak for the 1927 flood at Montpelier by converting elevations of flood marks to gage heights and gage heights to peak discharge on the basis of channel conditions at the gage. A similar procedure provided a reasonable estimate of the 1927 flood peak discharge at Essex Junction.

All gages except that on Sonny Brook recorded the peak rates of flow for the 1936 and 1938 floods.

Flood Description

The Great Flood of November 1927

By far the greatest flood, at least since 1830, to occur in the Winooski River Basin and, in particular, the Waterbury area, was that of November 2 through November 4, 1927. October had been a month with above average rainfall which had been well distributed over the four week period. The ground was well saturated and, by the end of October, most rain that fell remained on top of the ground to become surface runoff. The small water courses had flowed bankfull and the larger streams were flowing at well above normal flow rates.

On Wednesday, November 2, rain started to fall, gradually at first but with increasing intensity reaching cloudburst proportions at times before it tapered off to a drizzle on Friday. The storm area (briefly stated as the juncture of two storm areas) persisted over Central Vermont for an average of 45 hours, compared to a more common duration of 18 to 24 hours. During the 45 hour period 8.66 inches of rain were measured at Northfield, 7.13 inches of which were recorded during the first 24 hours of the storm.

According to the U.S. Weather Bureau at Burlington:

> "Some idea of the amount of water which such a rainfall represents may be gained by taking the Winooski basin as an example. This watershed contains, roughly, a thousand square miles of surface. An average of eight inches over one square mile produced 1,858,560 cubic feet of water. On a thousand square miles this means 1,800,000,000 cubic feet of water. In three months, according to meter readings in Burlington, the average family uses from 1,500 to 2,000 cubic feet. From this it readily appears that enough water fell on the Winooski basin in 45 hours to serve one million families for three months.
>
> "All of this water flowing into the narrow and low valleys within so short a time could have but one result: a flood which perhaps will not occur oftener than once or twice in a hundred years."

Portions of a detailed description by Atwood* of the 1927 flood in the Waterbury area reads as follows:

> "The Winooski overflowed its banks during the afternoon of November 3. At five o'clock it was above the highest previous water mark within the memory of the oldest inhabitant. A little later the course of the river was diverted, due to the wreckage piled against Duxbury bridge at the east end of the town, and the rushing torrent poured down the main street of the village. From seven until nine it rose at the rate of four feet an hour and from that time on, at about one foot an hour until it reached its highest point at 4 o'clock Friday morning, November 4. It is estimated to have been from 15 to 18 feet above any previous high water mark on record.

*Atwood, R.E., *Stories and Pictures of the Vermont Flood* November 1927; Burlington, Vt., 1927.

"With the dawn came the revelation of destruction. Houses, barns, and bridges were gone or left twisted about at odd angles. The water receded at the rate of a foot an hour, and on Friday evening mud was everywhere. It covered the streets, sidewalks, floors and furniture. Automobiles were buried in it. It was a sight that none will forget."

Johnson's* description is more detailed, parts reading as follows:

"The Winooski River and its tributaries accounted for more lives lost and more property destroyed than any other water flow in New England during the flood of 1927. As nearly as can be ascertained the dead numbered over fifty, while the property loss was fully $10,000,000. The chain of steep, narrow valleys, the numerous dams and bridges, and especially the large population and property valuation located either close beside the streams or not much above the normal water level all contributed to this end.

"Of all towns in Vermont, Waterbury, including its suburb, Duxbury Corner, just across the river, suffered worse, both in fatalities and property damage, considering the latter in proportion to the size of the town. The dead in Waterbury numbered fifteen, of whom thirteen were drowned.

"By 5 P.M. Thursday the Winooski was out of its banks, but this frequently happens and no concern was felt. Even when about 6 o'clock water appeared in the streets it occasioned little alarm. But the water deepened and the current strengthened very rapidly, rising a foot in fifteen minutes for two hours. Randall Street, nearest the river, took alarm first. Soon after 6 o'clock water was waist deep there and some residents waded or were carried to higher ground. Those marooned had to be removed by boats later that night.

"Early in the evening the dimensions of the flood began to appear. By 9 o'clock Main Street was under water and escape from homes impossible except in boats. Many stayed in their dwellings, taking to the upper floors, while a large number were brought to refuge on higher ground. The schoolhouse sheltered some four hundred refugees, while the Inn took in about two hundred and the Tavern many others.

"Two spans of the new iron bridge across the Winooski on South Main Street went out when the doubleway bridge between Middlesex and Waterbury came down the river and hit it. The Winooski Street bridge yielded to a tremendous water pressure from the river and a backup caused by debris along the line of trees bordering the village cemetery, where a barricade was found in some places fifteen feet high. Two houses and the Middlesex Bridge were the death of the railroad bridge, No. 71, downstream of Waterbury, which withstood three blows before giving way.

*Johnson, L.B., *Floodtide of 1927*, Randolph, Vt. 1927.

Figure 9
Randall Street looking toward State Hospital in 1927.

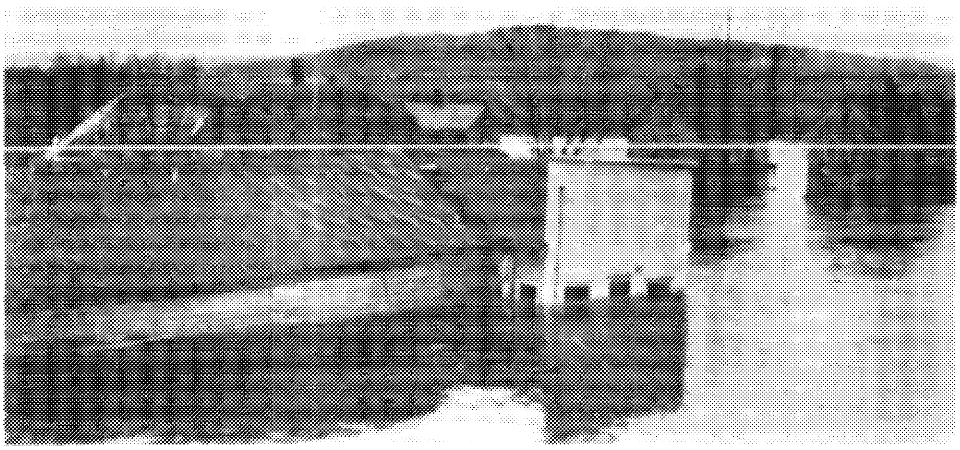


Figure 10 - North Main Street (November 1927). Showing water line on houses in background. Floating building in foreground.

Figure 11 - Main St. Waterbury; 1927 flood reached base of pole bearing telephone connection box in right foreground and to black horizontal line over window displaying flag.

"The Winooski Valley, over a mile wide at Waterbury, was a great, awe-inspiring lake. Water flowed over Main Street at varying depths according to the street level, but in many places it was ten and even fifteen feet deep in the street. At the high point of the flood the water reached just to the top of Bank Hill in the center of the town. The railroad station was submerged to its roof. Between six and seven feet of water flowed over the office floor at the Waterbury Inn. A train load of milk in the railroad yard was all but submerged and two trainmen spent the night on the water tower clinging to it.

"Only three houses in the northern part of the village were left dry. To these, refugees from that section were brought, the only other shelter being the wooded slopes of Sunset Hill.

"At the Vermont State Hospital the several hundred patients and the attendants were forced to the third floor, there being six feet of water on the second level. Only one life was lost, and order prevailed throughout. The dead man was Fred Cilley of Braintree and the superintendent expressed some doubt about his death being caused by drowning.

"The entire herd of 113 registered Holsteins of the State Hospital farm, with much other livestock, was lost.

"The property loss of all kinds in Waterbury was placed at $2,000,000.

"In the meantime an emergency Red Cross hospital had been established at the Gene Moody house and compulsory inoculation for typhoid was at once enforced. With water mains broken and sewerage lines stopped, the most rigid rules were enforced regarding sanitation. Armed guards were placed at frequent posts on the streets at night, to be later taken over by the army, which moved in on Monday, the 7th, and remained to police the town.

"The popular camping spot known as the Palisades, three miles upstream of Waterbury, was completely washed away, the ground level through the entire width of the valley being lowered at least twenty feet. This section is now a dry river bed covered with boulders, with the bed rock exposed in many places."

FUTURE FLOODS

Floods of the same or larger magnitude as those that have occurred in the past in the Waterbury area could occur in the future. Larger floods have been experienced in the past on streams with similar geographical and physiographical characteristics as those found in the study area. Similar combinations of rainfall and runoff which caused these floods could occur in the Waterbury area. Therefore, to determine the flooding potential of the study area, it was necessary to consider not only storms and floods that have occurred in the Winooski River Watershed but also floods that have occurred in other regions of like topography, watershed cover, flood plain development and physical characteristics.

Discussion of future floods in this report is limited to those that have been designated as the Intermediate Regional Flood and the Standard Project Flood. The Standard Project Flood represents a reasonable upper limit of expected flooding in the study area. The Intermediate Regional Flood reasonably may be expected to occur more frequently although it will not be as severe as the infrequent Standard Project Flood.

Intermediate Regional Flood

The Intermediate Regional Flood is defined as one that would occur once in 100 years on the average, although it could occur in any year. Such a flood may also be thought of as having a one per cent chance of occurring or being exceeded in any one year. The peak flow of this flood was developed from statistical analyses of streamflow and precipitation records and runoff characteristics for the Winooski River Watershed. Peak flows thus developed for the Intermediate Regional Flood for selected locations in the study are shown in Table 2.

Standard Project Flood

The Standard Project Flood is defined as a major flood that can be expected to occur from a severe combination of meteorological and hydrologic conditions that are considered reasonably characteristic of the geographical region in which the study area is located excluding extremely rare combinations. The Corps of Engineers, in cooperation with the NOAA Weather Service, has made comprehensive studies and investigations based on the past records of experienced storms and floods and has developed generalized procedures for estimating the flood potential of streams. Peak discharges for the Standard Project Flood at selected locations in the study area are shown in Table 2. The relative water surface elevations for the Intermediate Regional Flood and the Standard Project Flood at the cross sections taken for this study are in Tables 3 and 4 on page 19. The water surface profiles for the Intermediate Regional Flood and the Standard Project Flood are shown on Plates 9 and 10.

TABLE 2
PEAK FLOWS - WINOOSKI RIVER BASIN

Site	River Mile	Drainage Area [Sq. Mi.]	Intermediate Regional Flood cfs	Standard Project Flood cfs	1927 Flood cfs
Winooski R. below Mad R.	48.5	706	60,000	140,000	71,000
Thatcher Brook at Mouth		20	3,000	8,000	
Winooski R. above Little R.	42.0	720	67,000	145,000	88,100
Little R. at Mouth (Regulated)		111	3,720	5,000	23,400*
Winooski R. at Bolton Falls	39.8	848	70,000	150,000	98,500

*Unregulated.

Frequency

No numerical frequency has been assigned to the Standard Project Flood. The occurrence of such a flood would be a rare event, but it could happen in any year.

Floods larger than the Standard Project Flood are possible; however, the combination of factors that would be necessary to produce such floods rarely would occur.

Hazards of Large Floods

The extent of damage caused by any flood depends on the magnitude of the flood peak, the topography of the area flooded, depth and duration of flooding, velocity of flow, rate of rise, and development on the flood plain. An Intermediate Regional Flood or Standard Project Flood on the Winooski River, Little River and Thatcher Brook would result in inundation of residential, commercial, governmental, agricultural, and industrial sections in the Waterbury area. Deep floodwater flowing at high velocity and carrying floating debris and/or ice would create conditions hazardous to persons and vehicles attempting to cross flood areas, as well as to any livestock pastured in the floodway. In general, water flowing three or more feet deep at a velocity of three or more feet per second could easily sweep an adult person off his feet, thus creating danger of injury or drowning. Rapidly rising and swiftly moving floodwater may trap persons in homes that are ultimately destroyed, or in

TABLE 3
WINOOSKI RIVER FLOOD CREST ELEVATIONS

Site	Miles Above Mouth	Elevations in Feet Above Mean Sea Level: Streambed Elevation	Intermediate Regional Flood	Standard Project Flood	1927 Flood
Bolton Dam	39.60	382.1 (Crest)	403.2	412.4	434.0
Downstream from Little River	41.72	393.9	418.3	428.7	434.7
U.S. Central Vermont Railroad Bridge	42.14	394.2	421.8	434.0	434.7
Waterbury STP	43.27	396.7	428.5	440.6	435.0
Winooski Street	43.45	400.8	429.0	440.9	435.6
Hospital Steam Plant	43.89	394.7	430.3	441.3	436.0
South Main Street Bridge	44.68	405.6	434.0	442.0	439.0
Town Line	46.73	391.1	439.4	450.0	447.0

TABLE 4
LITTLE RIVER FLOOD CREST ELEVATIONS

Site	Miles Above Mouth	Elevations in Feet Above Mean Sea Level: Streambed Elevation	Intermediate Regional Flood	Standard Project Flood
Route 2 Bridge	0.12	398.8	419.3	431.1
Old Route 2 Bridge	0.17	399.8	419.5	431.3
Town Line [2]	0.66	403.6	419.6	431.4

THATCHER BROOK FLOOD CREST ELEVATIONS

Site	Miles Above Mouth	Elevation in Feet Above Mean Sea Level: Streambed Elevation	Intermediate Regional Flood	Standard Project Flood
Mouth	0.00		427.8	440.3
Armory Drive	0.19	404.4	427.9	440.4
Route I-89	0.83	418.0	428.0	440.5
Stowe Street	1.11	489.9	496.5	501.0

mobile homes or vehicles that may become submerged or swept downstream. Water lines may be ruptured, thus creating the possibility of contaminated domestic water supplies. Damaged sewer lines and wastewater treatment plants could result in pollution of the flood water creating health hazards. Isolation of areas by floodwater could create hazards in terms of medical, fire, or law enforcement emergencies.

Flooded Areas and Flood Damages

The areas along the Winooski River, Little River and Thatcher Brook that would be flooded by the Intermediate Regional and Standard Project Floods are shown in detail on Plates 3 through 8. The actual limits of these overflow areas may vary somewhat from those shown on the maps because the 5 foot contour interval and horizontal scale of the maps do not permit precise plotting of the flooded area boundaries. As may be seen from these plates, floodflows from the Winooski River and its tributaries, Little River and Thatcher Brook, would cover a large portion of the Village of Waterbury, together with vast overflow sections east, south and west of the Village. Damage from floodflows on the tributaries would be relatively small except where backwater from the main river extended up the tributary channels. The areas that would be flooded by the Intermediate Regional and Standard Project Floods would include commercial, industrial, governmental and residential sections including streets, roads, bridges, and private and public utilities. Plates 9 and 10 show water surface profiles of the Standard Project and Intermediate Regional Floods. Water surface elevations at 8 cross sections on Winooski River within the study area, three cross sections on Little River, and four cross sections on Thatcher Brook are included in Tables 3 and 4. Depths of flow in the main channel can be estimated from these illustrations. Typical cross sections of the stream valley at selected locations, together with the water surface elevation and lateral extent of the Intermediate Regional and Standard Project Floods are shown on Plates 11 and 12.

Tributary streams entering the delineated flooded areas may experience flooding from local runoff.

Obstructions

During floods, debris and/or ice collecting at bridges and other constrictions could decrease their carrying capacity and cause higher water surface elevations (backwater effect) upstream of the structures. Since the amount and occurrence of debris and/or ice are indeterminate factors, only the physical characteristics of the structures and other constrictions were considered in preparing the profiles of the Standard Project and Intermediate Regional Floods. Similarly, the maps of the flooded areas show the normal backwater effect of obstructive bridges and constrictions, but do not reflect increased water surface elevations that could be caused by debris and/or ice collecting against the structures or by deposition in the stream channel under structures.

The only major dam, that at Bolton Falls on the Winooski River at the extreme downstream end of the study area, has no appreciable flood control capacity since it is spilling almost continuously except during periods of low stream stages when all flow passes through the dam as leakage. The dam does have a limited influence on the water surface elevation for a short distance upstream but the influence is rapidly lost by the constricting effect of Bolton Gorge. The remains of three small dams on Thatcher Brook serve little more than to stabilize the streambed in the immediate vicinity of the dams.

All three bridges over the Winooski River within the study area are obstructive to the Intermediate Regional Flood and even more so to the Standard Project Flood. In cases where the bridge structure is not inundated, the approaches may be lower than the structure and subject to flooding and rendered impassable. Table 5 on Page 21 lists the pertinent data relative to all bridges within the study area.

In addition, there are five bridges spanning Thatcher Brook and three across Little River within the study area. Only the structures carrying Interstate Route I-89 and a ramp over Thatcher Brook, and Route I-89 and U.S. 2 over Little River are high and unobstructive (see Table 5). The other bridges over these two tributaries obstruct flood flows with all but one of these bridges being within the backwater effect from Winooski River.

Velocities of Flow

The velocity of water flowing during a flood depends largely on the magnitude of the flood flow, the size and shape of the valley cross section, conditions of the channel and overflow plain, and the bed slope, all of which vary on different streams and at different locations on the same stream. During the Intermediate Regional Flood, velocities of flow in the main channel of the Winooski River within the study area would vary up to 19 feet per second (13 miles per hour). Water flowing at this rate is capable of eroding the stream channel and banks and fill around bridge abutments, and transporting large objects. Velocities of flow during a Standard Project Flood would be somewhat greater. Overbank flow velocity would average one to five feet per second. Water flowing at two feet per second or less would deposit debris and silt.

Rates of Rise and Duration of Flooding

Under present conditions with the detention reservoirs at East Barre and Wrightsville in operation, and with the large volumes of storage provided on the flood plain, the rate of rise in water surface elevation in the Waterbury area would be less rapid than on a stream of similar size and topography with less extensive flood plain and no flood control facilities. The duration of flooding might be increased, however. A reasonable estimate of rate of rise for the Intermediate Regional Flood in the Waterbury area would be 12 hours from beginning of rise to the peak with total duration of flooding of 40 hours. Both rate of rise and duration of flooding could vary during a particular flood depending on distribution of rainfall throughout the Winooski River Basin.

TABLE 5
ELEVATION DATA
BRIDGES ACROSS WINOOSKI RIVER, LITTLE RIVER AND THATCHER BROOK IN WATERBURY AREA

			Water Surface Elevation*		
Site	**Mileage Above Mouth**	**Under-clearance Elevation***	**Intermediate Regional Flood**	**Standard Project Flood**	**1927 Flood**
	Winooski River				
CV Railroad	42.10	420.8	419.7	429.8	434.7
Winooski St.	43.44	421.6	428.6	440.9	435.6
So. Main St.	44.66	426.2	433.0	441.8	439.0
	Little River				
Route 2	0.04	429.0	419.3	431.1	434.7
I-89	0.12	446.2	419.4	431.2	
Old Route 2	0.17	416.2	419.5	431.3	
	Thatcher Brook				
CV Railroad	0.10	431.8	427.8	440.3	435.0
Rtes 2 and 100	0.10	415.2	427.8	440.3	
Armory Drive	0.19	414.2	427.9	440.4	
I-89	0.83	464.8	428.0	440.5	
Stowe St. Br.	1.11	505.3	496.5	501.0	

*Elevation in feet above mean sea level.

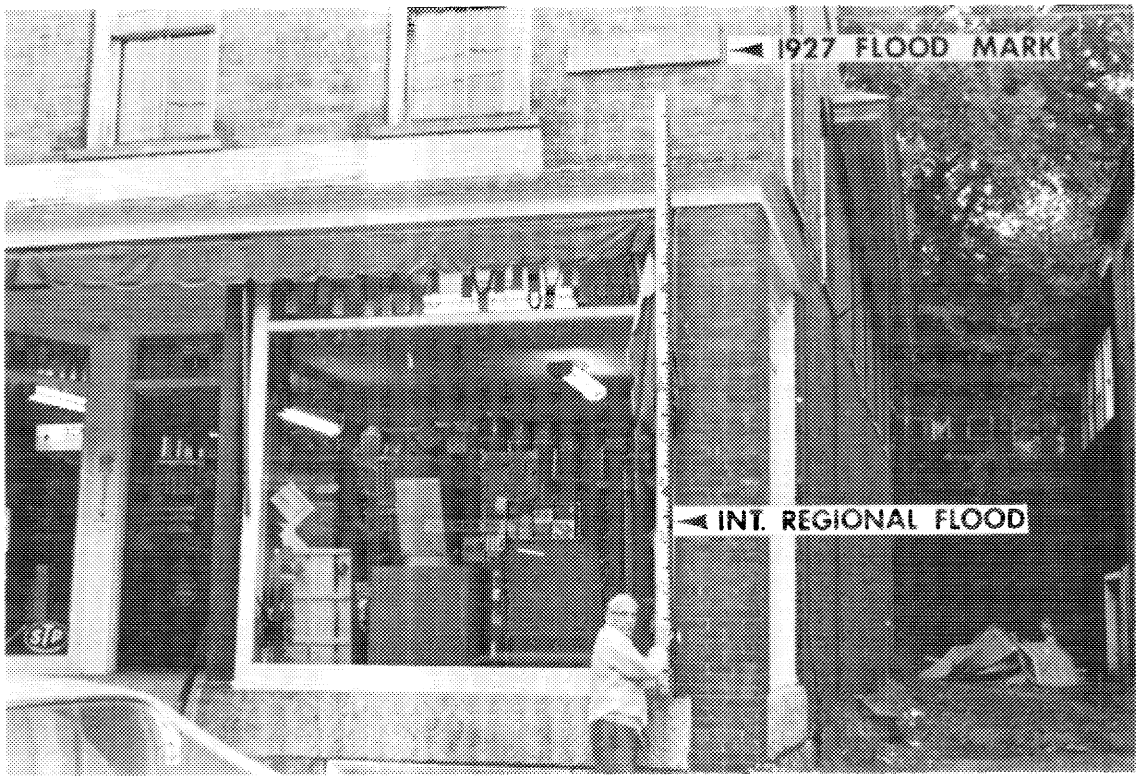


Figure 12 - 1927 highwater mark on Elm Street building, near corner of Main Street. IRF would reach point indicated. SPF would be 12 ft. higher.

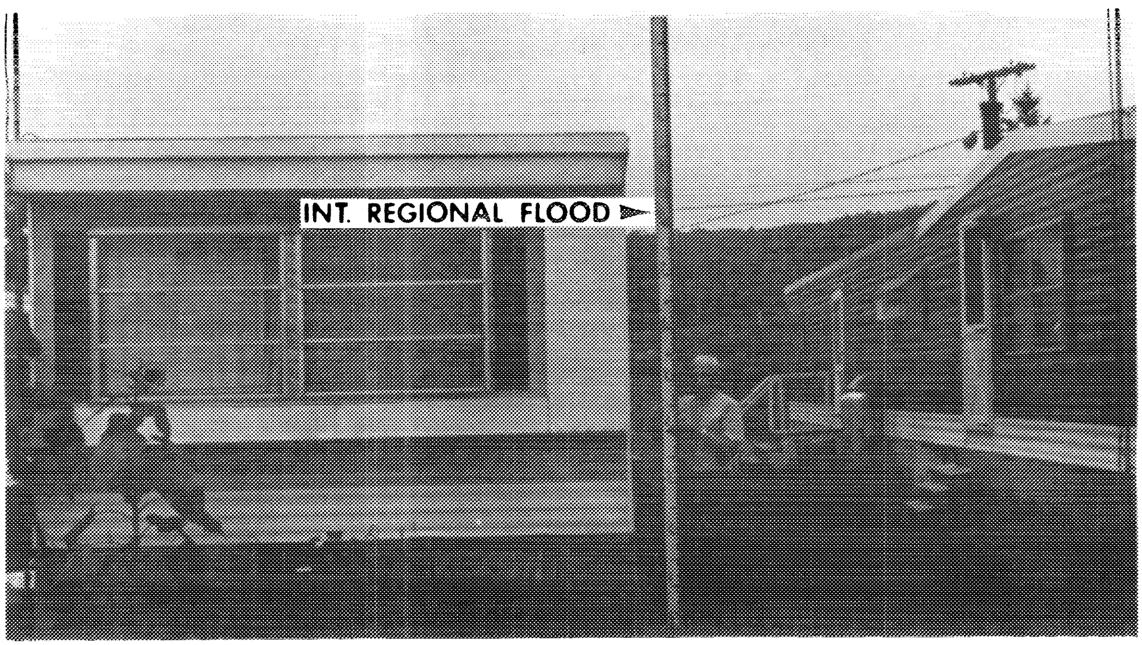


Figure 13 - Mobile home on O'Hear Court. The SPF would reach a rod reading of 12 ft. higher than that shown for the IRF.

Figure 14 - Waterbury Wastewater Treatment Plant, showing projected elevation of IRF.

Figure 15 - Waterbury State Hospital Wastewater Treatment Plant showing future flood elevation.

Figure 16 - Steam plant at Waterbury State Hospital showing relative flood heights. SPF would exceed IRF by 11 ft.

Figure 17 - Future flood heights at laundry building at State Hospital. SPF would exceed IRF by 11 ft.

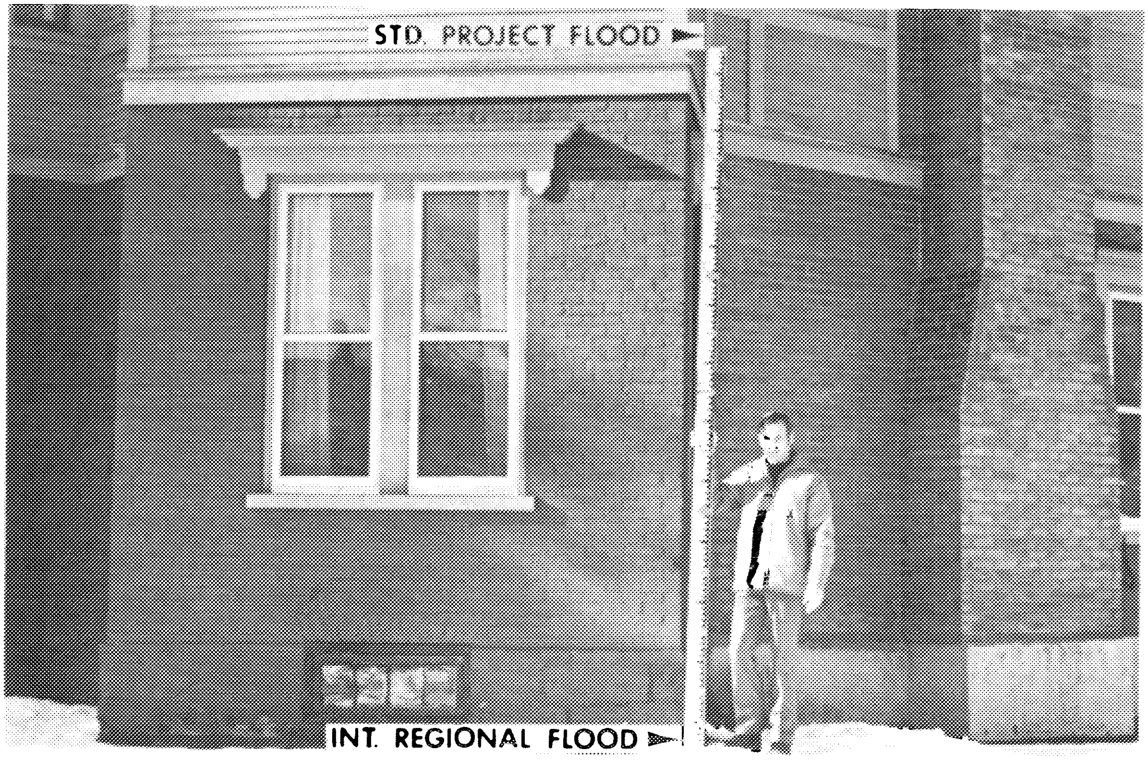


Figure 18 - Future flood heights at Waterbury Public Library.

Figure 19 - Future flood height at Waterbury Municipal Building.

GLOSSARY

Backwater. The resulting high water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.

Flood. An overflow of lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: The inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river, stream, ocean, lake, or other body of standing water.

Normally a "flood" is considered as any temporary rise in streamflow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased streamflow, and other problems.

Flood Crest. The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Plain. The areas adjoining a river, stream, watercourse, ocean, lake, or other body of standing water that have been or may be covered by floodwater.

Flood Profile. A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above mouth for a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the crest of a specific flood, but may be prepared for conditions at a given time or stage.

Flood Stage. The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Floodway. That portion of the channel and flood plain which is covered by flowing water during a flood as contrasted to that portion of the flood plain where water is ponded with no appreciable velocity of flow.

Hydrograph. A graph showing flow values against time at a given point, usually measured in cubic feet per second. The area under the curve indicates total volume of flow.

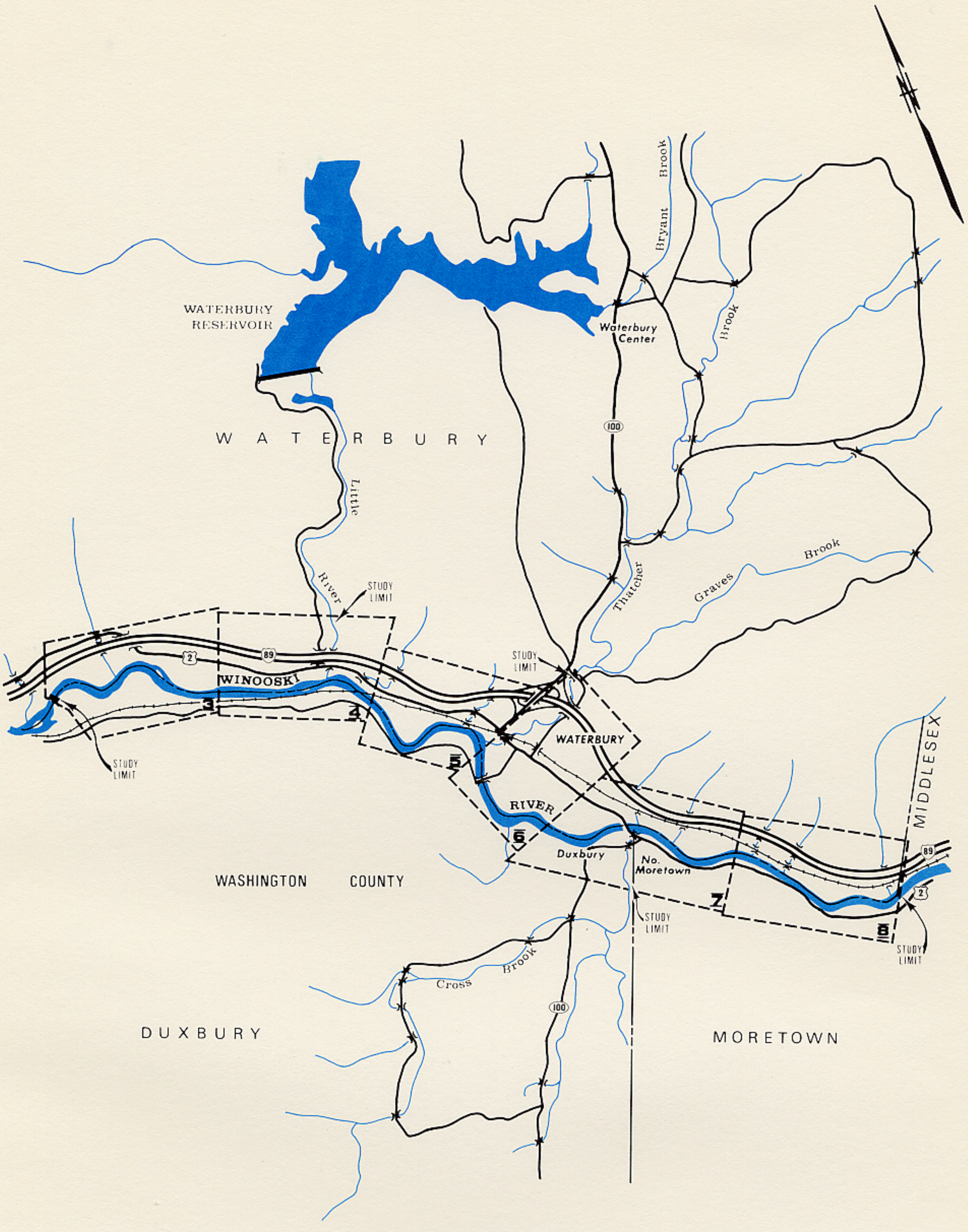
Intermediate Regional Flood. A flood having an average frequency of occurrence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the general region of the watershed.

Left Bank. The bank on the left side of a river, or watercourse, looking downstream.

Right Bank. The bank on the right side of a river, stream, or watercourse, looking downstream.

Standard Project Flood. The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharge for this flood is generally about 40-60 per cent of the Provable Maximum Flood for the basin. As used by the Corps of Engineers, Standard Project Floods are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Underclearance Elevation. The elevation at the top of the opening of a culvert, or other structure through which water may flow along a watercourse.



LEGEND

3 **Plate Number**

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

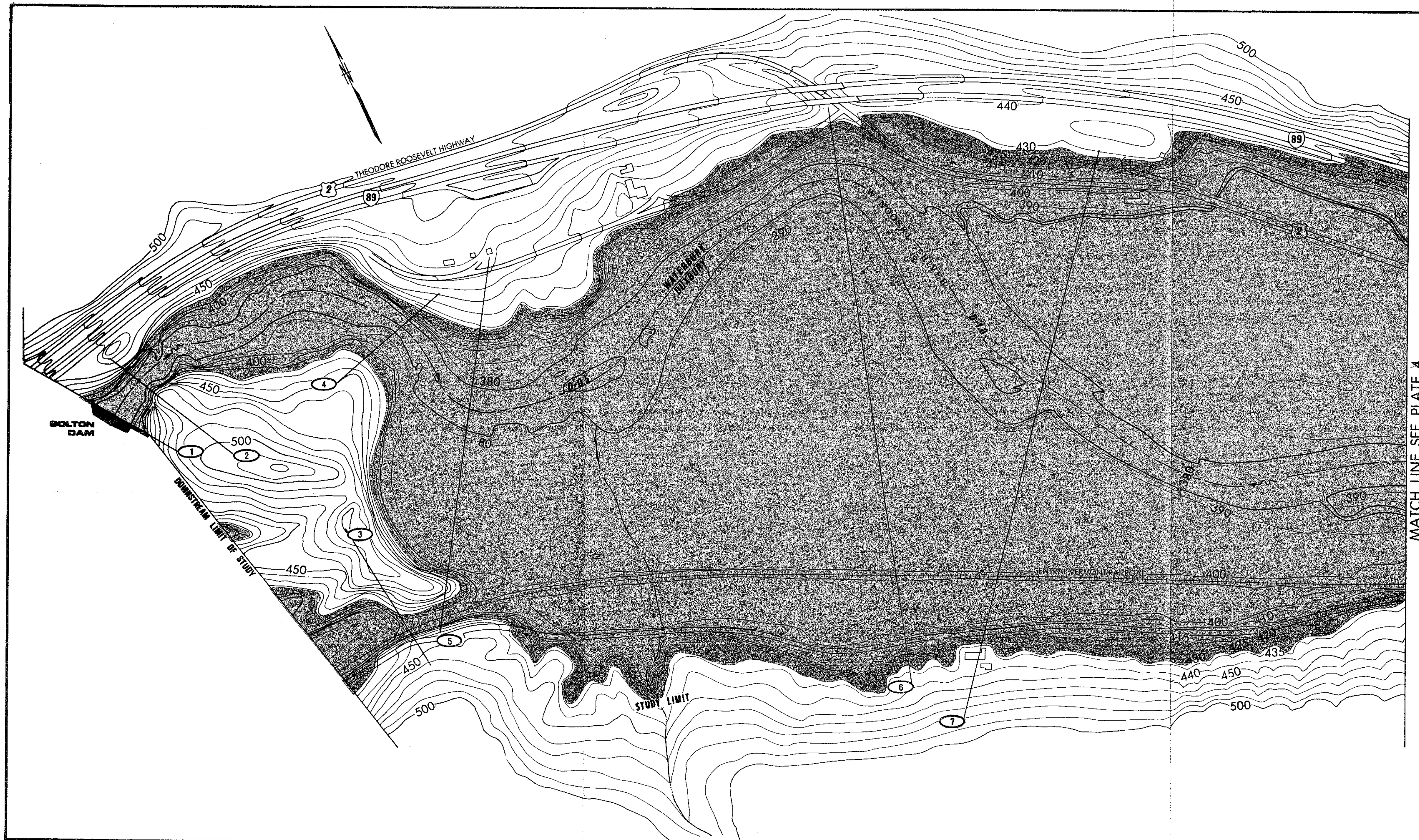
INDEX MAP

WINOOSKI RIVER
LITTLE RIVER
THATCHER BROOK

TOWN OF WATERBURY, VERMONT

2850 0 2850 5700 FEET

MARCH 1973



LEGEND

CHANNEL > INTERMEDIATE REGIONAL FLOOD > STANDARD PROJECT FLOOD

D+3.5 — MILES ABOVE BOLTON DAM

(6) — CROSS SECTION

525 — GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

— — — TOWN LINE

NOTES:

1. MAP IS BASED ON PHOTOGRAMMETRY, V.S.H.D. PLANS, AND FIELD SURVEYS BY V.S.D.W.R.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOODWAY MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. CONTOUR INTERVAL IS AS SHOWN

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

FLOODED AREAS

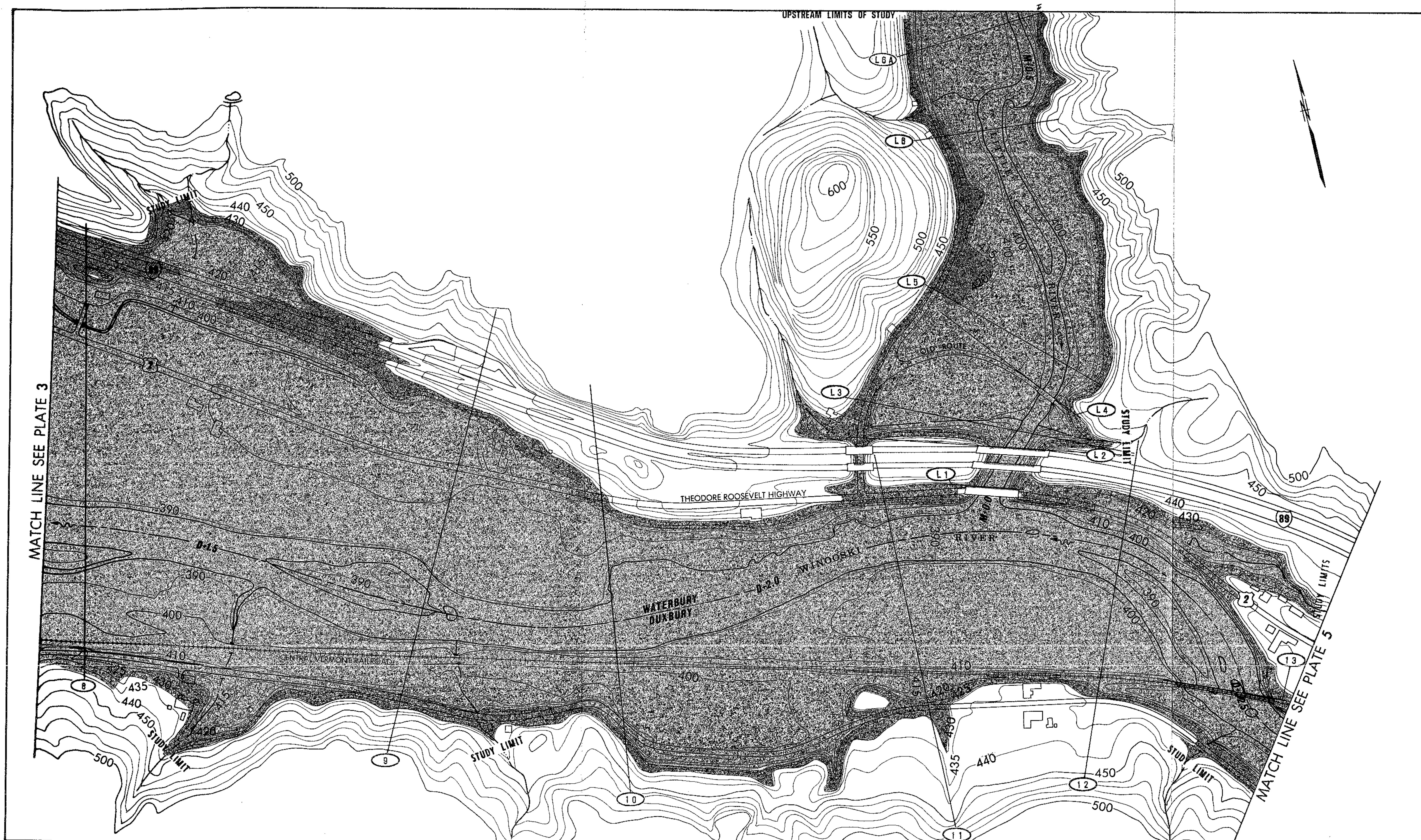
WINOOSKI RIVER

TOWN OF WATERBURY, VERMONT

SCALE IN FEET

200 0 200 400 600

MARCH 1973



LEGEND

CHANNEL — INTERMEDIATE REGIONAL FLOOD — STANDARD PROJECT FLOOD

D•3.5	MILES ABOVE BOLTON DAM
M•2.5	MILES ABOVE MOUTH
(6)	CROSS SECTION
525	GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
— —	TOWN LINE

NOTES:

1 MAP IS BASED ON PHOTOGRAMMETRY, VSHD PLANS, AND FIELD SURVEYS BY VSDWR

2 LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT

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4 CONTOUR INTERVAL IS AS SHOWN

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

FLOODED AREAS

WINOOSKI RIVER
LITTLE RIVER
TOWN OF WATERBURY, VERMONT

SCALE IN FEET

200 0 200 400 600

MARCH 1973

LEGEND
CHANNEL
INTERMEDIATE REGIONAL FLOOD
STANDARD PROJECT FLOOD
D+3.5 MILES ABOVE BOLTON DAM
M+2.5 MILES ABOVE MOUTH
6 CROSS SECTION
525 GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
TOWN LINE
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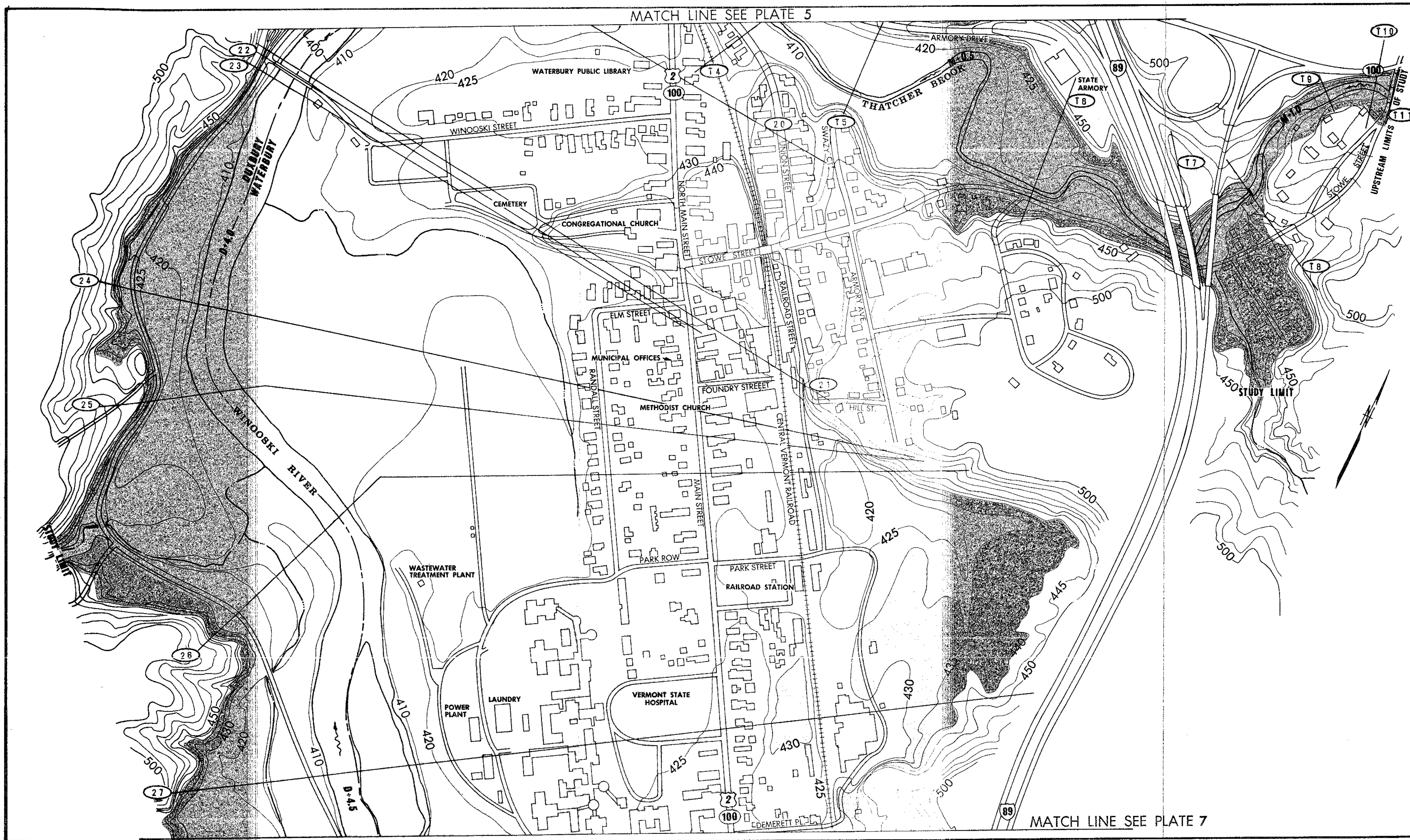
2 LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3 AREAS OUTSIDE THE FLOODWAY MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF
4 CONTOUR INTERVAL IS AS SHOWN
MATCH LINE SEE PLATE 4
MATCH LINE SEE PLATE 6
THEODORE ROOSEVELT HIGHWAY
CENTRAL VERMONT RAILROAD
WINOOSKI RIVER
THATCHER BROOK
WASTEWATER TREATMENT PLANT
POOL
O'HEAR COURT
WATERBURY
DUXBURY
LIMIT STUDY
D+3.0
D+3.5
M+0.0
DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK
FLOODED AREAS
WINOOSKI RIVER
THATCHER BROOK
TOWN OF WATERBURY, VERMONT
SCALE IN FEET
200 0 200 400 600
MARCH 1973



LEGEND

CHANNEL — INTERMEDIATE REGIONAL FLOOD — STANDARD PROJECT FLOOD

D+3.5 MILES ABOVE BOLTON DAM

M+2.5 MILES ABOVE MOUTH

(6) CROSS SECTION

525 GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

TOWN LINE

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DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

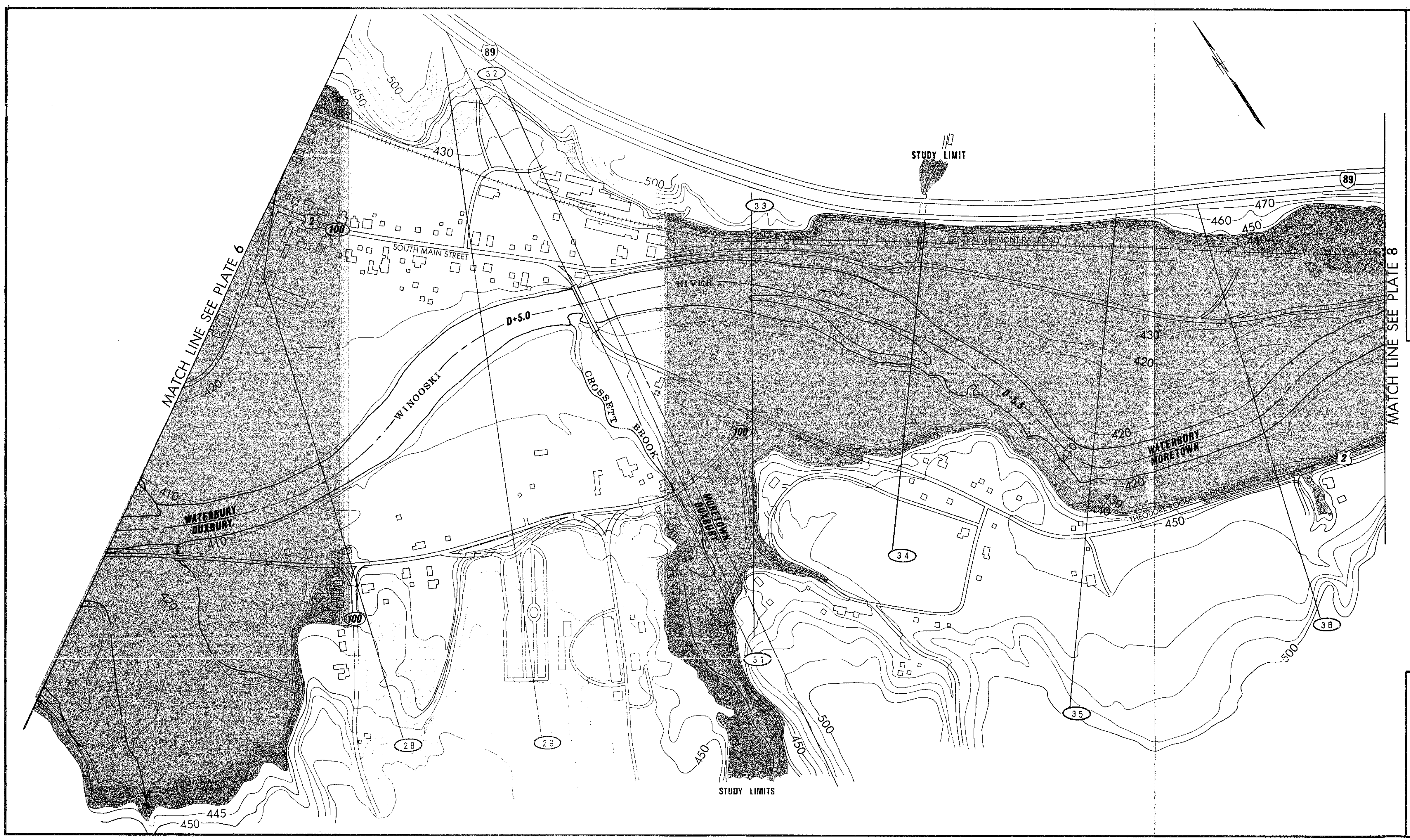
FLOODED AREAS

WINOOSKI RIVER
THATCHER BROOK
TOWN OF WATERBURY, VERMONT

SCALE IN FEET

200 0 200 400 600

MARCH 1973



LEGEND

CHANNEL — INTERMEDIATE REGIONAL FLOOD — STANDARD PROJECT FLOOD

D+3.5 MILES ABOVE BOLTON DAM

(6) CROSS SECTION

525 GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

TOWN LINE

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DEPARTMENT OF THE ARMY
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NEW YORK, NEW YORK

FLOODED AREAS

WINOOSKI RIVER

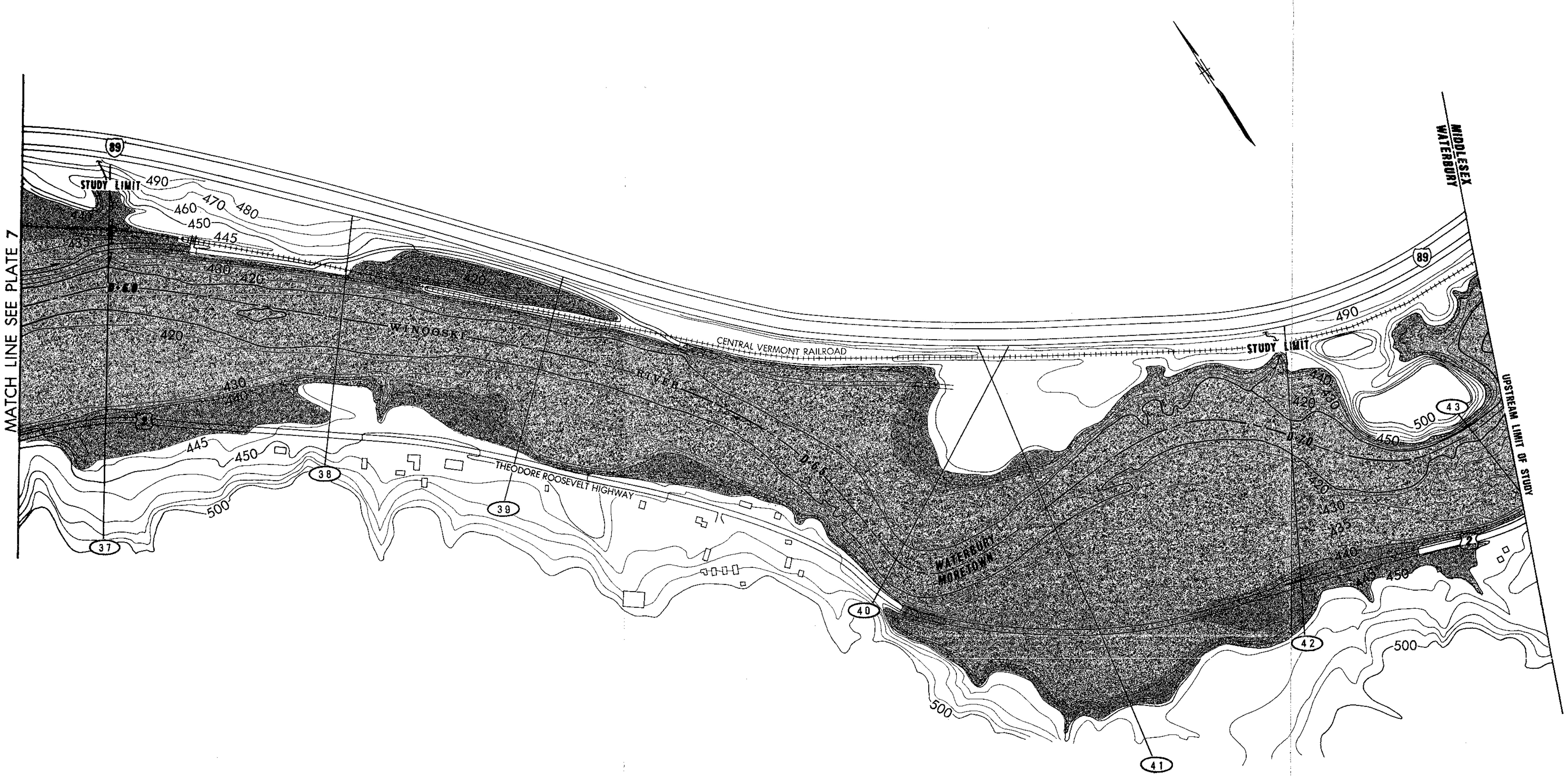
TOWN OF WATERBURY, VERMONT

SCALE IN FEET

200 0 200 400 600

MARCH 1973

PLATE 7



LEGEND

CHANNEL > INTERMEDIATE REGIONAL FLOOD > STANDARD PROJECT FLOOD

D+3.5 MILES ABOVE BOLTON DAM

(6) CROSS SECTION

525 GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

TOWN LINE

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DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

FLOODED AREAS

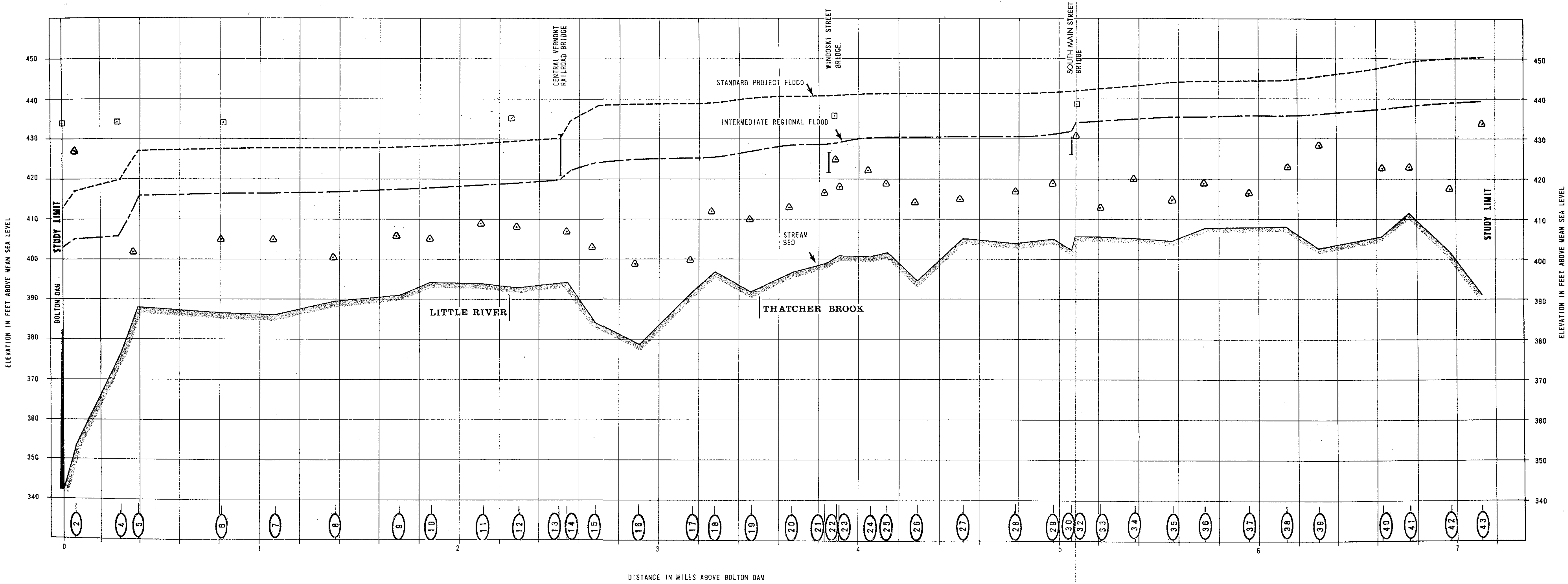
WINOOSKI RIVER

TOWN OF WATERBURY, VERMONT

SCALE IN FEET

200 0 200 400 600

MARCH 1973



LEGEND

STANDARD PROJECT FLOOD
INTERMEDIATE REGIONAL FLOOD
STREAM BED
3 CROSS SECTION
TOP OF LOW BANK
1927 FLOOD ELEVATION
BRIDGE DECK
UNDERCLEARANCE

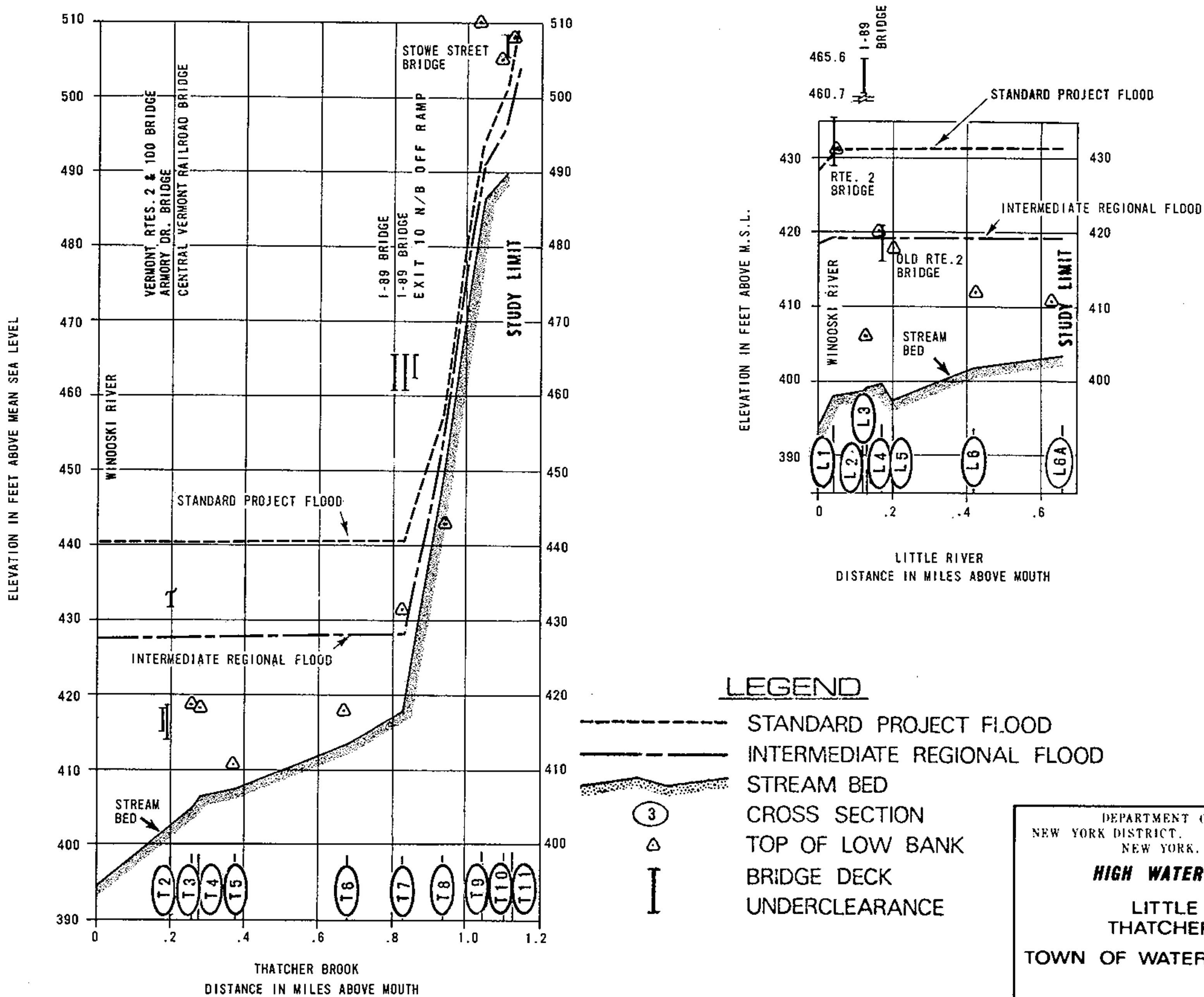
DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

HIGH WATER PROFILES

WINOOSKI RIVER

TOWN OF WATERBURY, VERMONT

MARCH 1973



LEGEND

STANDARD PROJECT FLOOD

INTERMEDIATE REGIONAL FLOOD

STREAM BED

3 CROSS SECTION

TOP OF LOW BANK

BRIDGE DECK

UNDERCLEARANCE

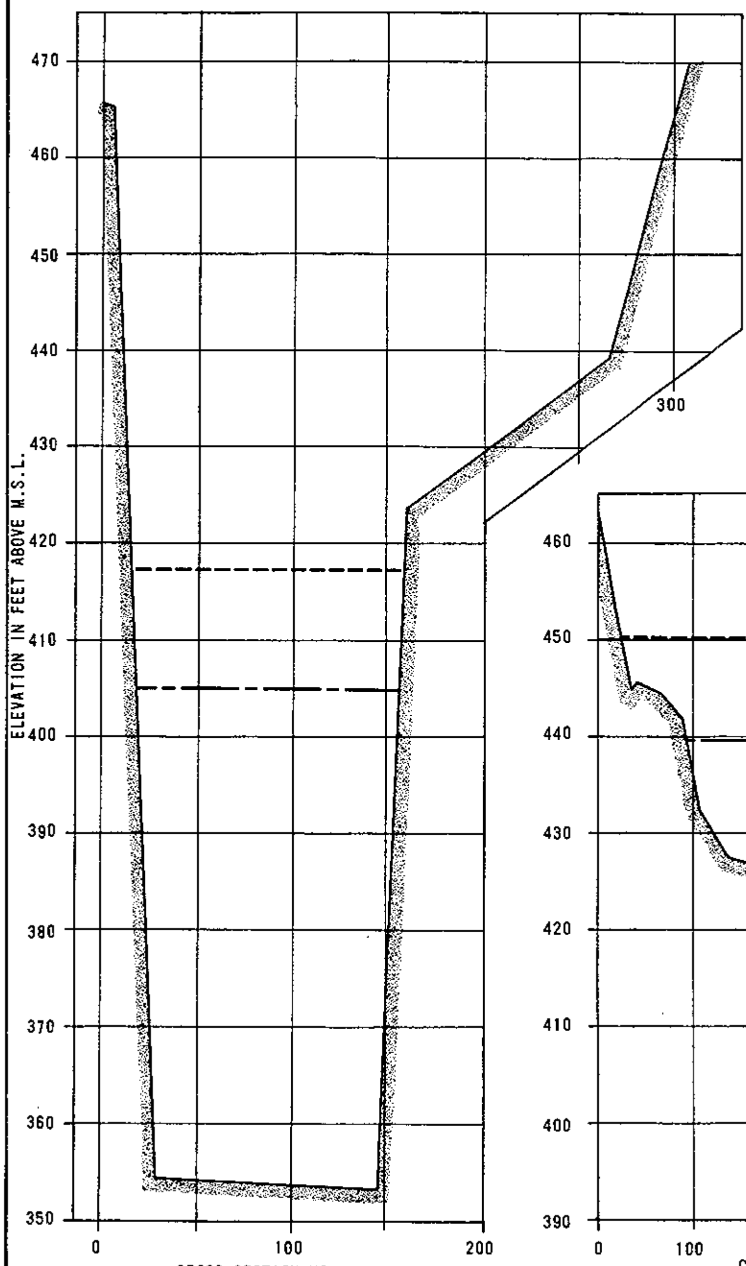
DEPARTMENT OF THE ARMY
NEW YORK DISTRICT. CORPS OF ENGINEERS
NEW YORK, NEW YORK

HIGH WATER PROFILES

LITTLE RIVER
THATCHER BROOK

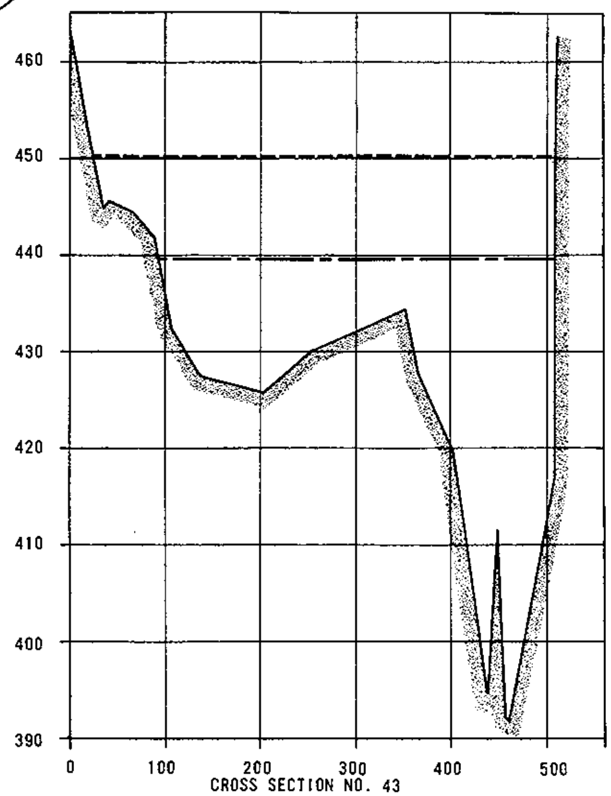
TOWN OF WATERBURY, VERMONT

MARCH 1973



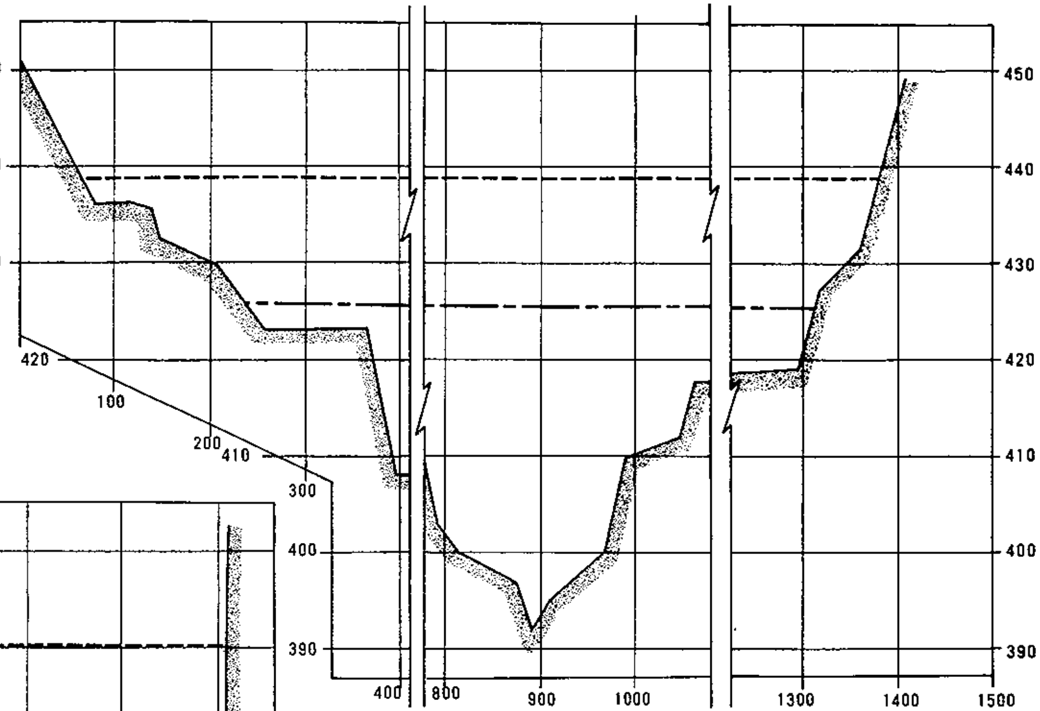
CROSS SECTION NO. 2

RIVER MILE D + 0.13



CROSS SECTION NO. 43

RIVER MILE D + 7.19



CROSS SECTION NO. 17

RIVER MILE D + 3.23

LEGEND

- - - - - STANDARD PROJECT FLOOD

— - — INTERMEDIATE REGIONAL FLOOD

▒▒▒ GROUND LINE

NOTES:

1. SECTIONS TAKEN LOOKING DOWNSTREAM.
2. ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
3. HORIZONTAL DISTANCES ARE IN FEET.

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

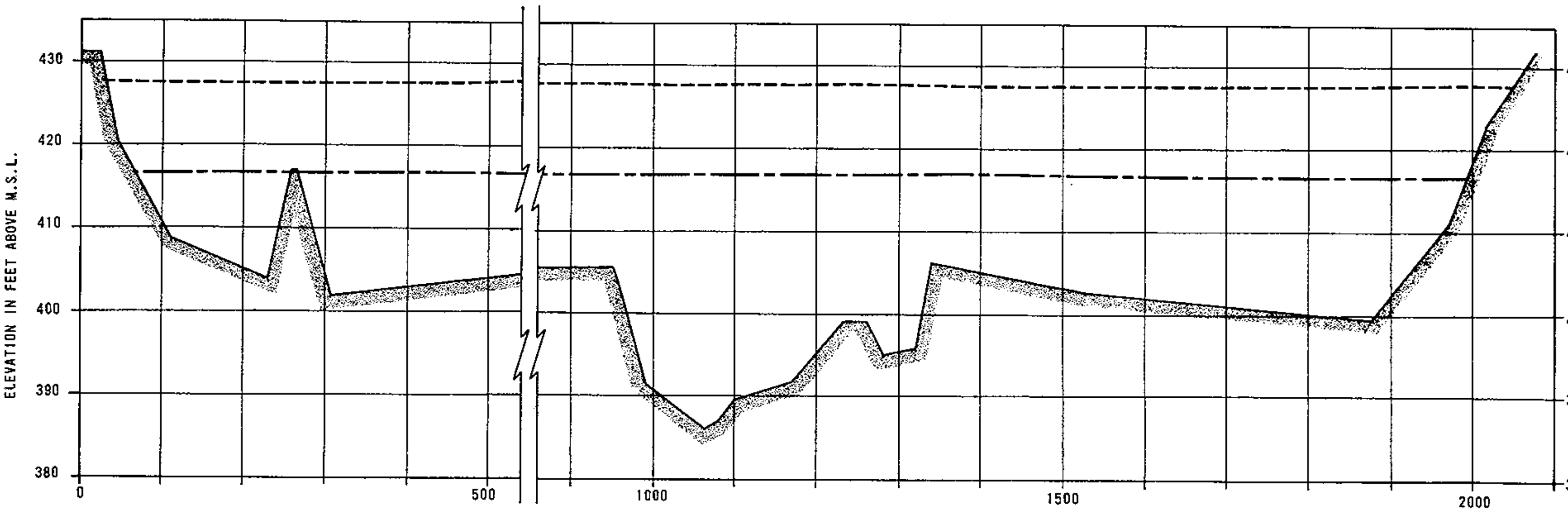
SELECTED CROSS SECTIONS

WINOOSKI RIVER

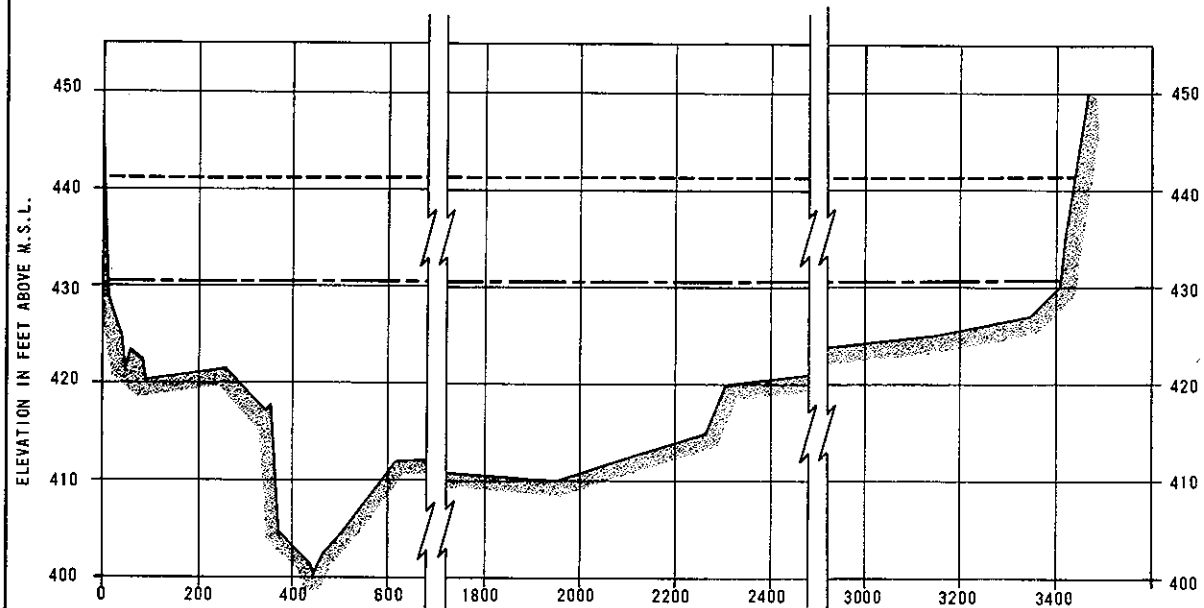
TOWN OF WATERBURY, VERMONT

MARCH 1973

PLATE 11



CROSS SECTION NO. 7
RIVER MILE D + 1.14



CROSS SECTION NO. 24
RIVER MILE D + 4.12

LEGEND

STANDARD PROJECT FLOOD
INTERMEDIATE REGIONAL FLOOD
GROUND LINE

NOTES:

1. SECTIONS TAKEN LOOKING DOWNSTREAM.
2. ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
3. HORIZONTAL DISTANCES ARE IN FEET.

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

SELECTED CROSS SECTIONS

WINOOSKI RIVER
TOWN OF WATERBURY, VERMONT

MARCH 1973

PLATE 12